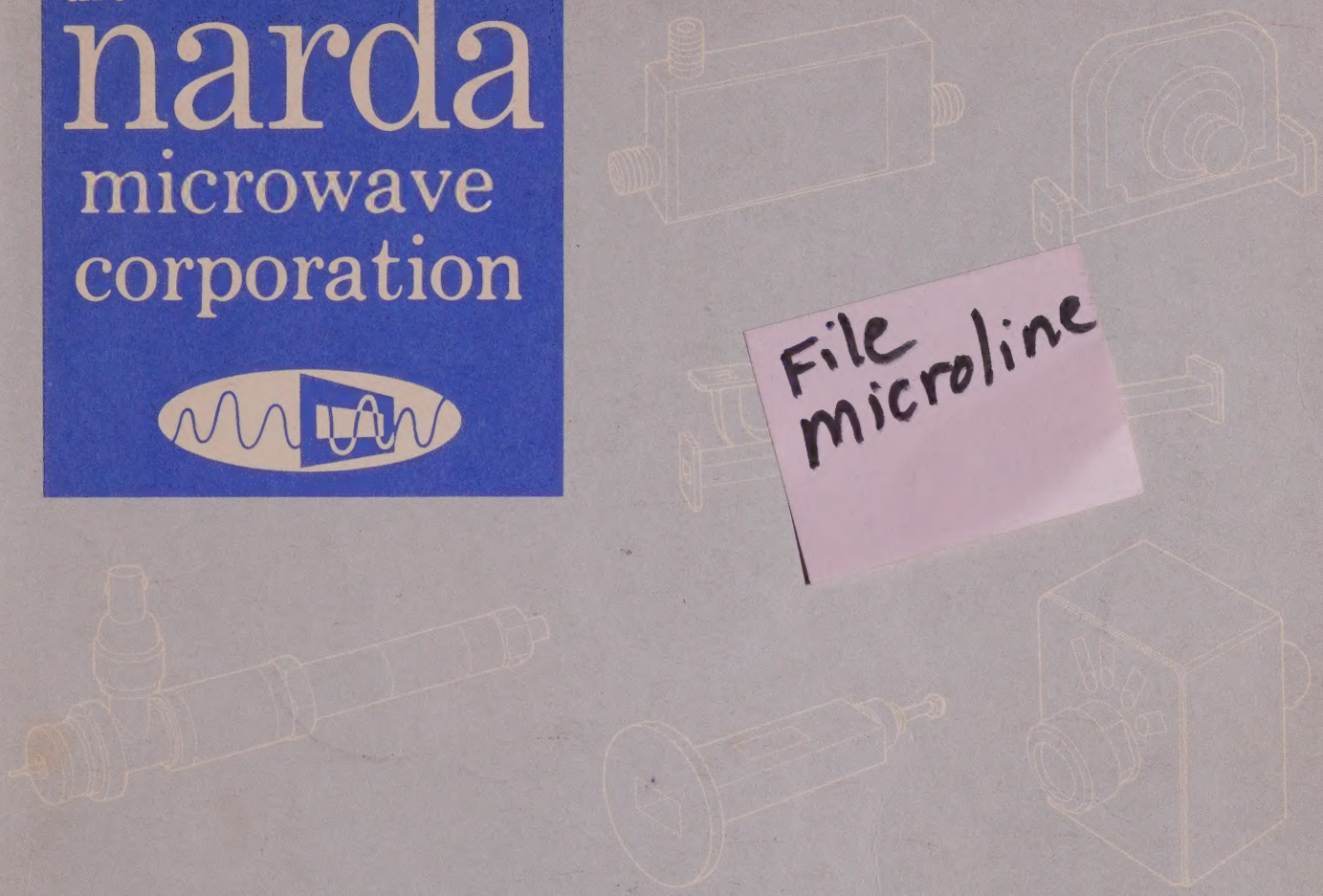
the narda microwave corporation

File microline

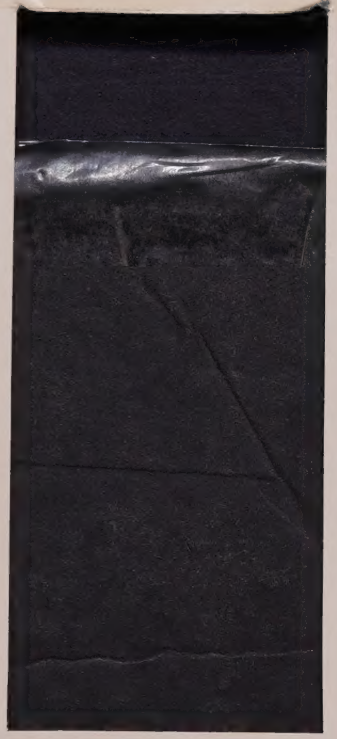


narda *Microline*

Model 62A1

UNIVERSAL KLYSTRON POWER SUPPLY

microwave and uhf electronic test equipment



narda *Microline*

Model 62A1
UNIVERSAL KLYSTRON POWER SUPPLY

(Serial No. 257 up)

Publication No. SJ-26-0023E October 1965

ERRATA SHEET NO. 1

PUBLICATION SJ-26-0023E

MODEL 62A1 UNIVERSAL KLYSTRON POWER SUPPLY

Page 21 In the first column, line three under the paragraph entitled "Control Grid Bias Voltages," change the line to read ..... between pins C and B at ..... instead of pins C and A.

Page 22 Change the first line in the first column to read "than 3 microseconds" instead of "than 2 microseconds."

Page 30 Change the part number for K2 from B-02601 to B-02603.

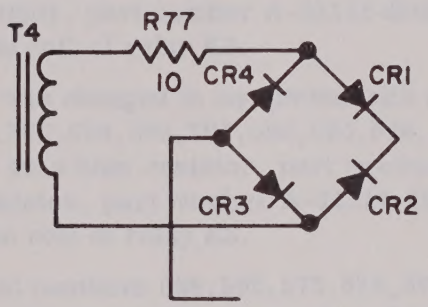
Page 32 Add part number A-01171-253 for resistor R43.

ERRATA SHEET NO. 2

Publication SJ-26-0023E

MODEL 62A1 UNIVERSAL KLYSTRON POWER SUPPLY

Page 37 - 38. Correct bridge circuit as follows:



Page 33. Change the part number of R111 from A-01152-254 to A-01168-254.

ERRATA SHEET No. 3

Publication SJ-26-0023E

MODEL 62A1 UNIVERSAL KLYSTRON POWER SUPPLY

Page 29. Change the part number of capacitor C101 from A-01217-101 to A-01217-102.

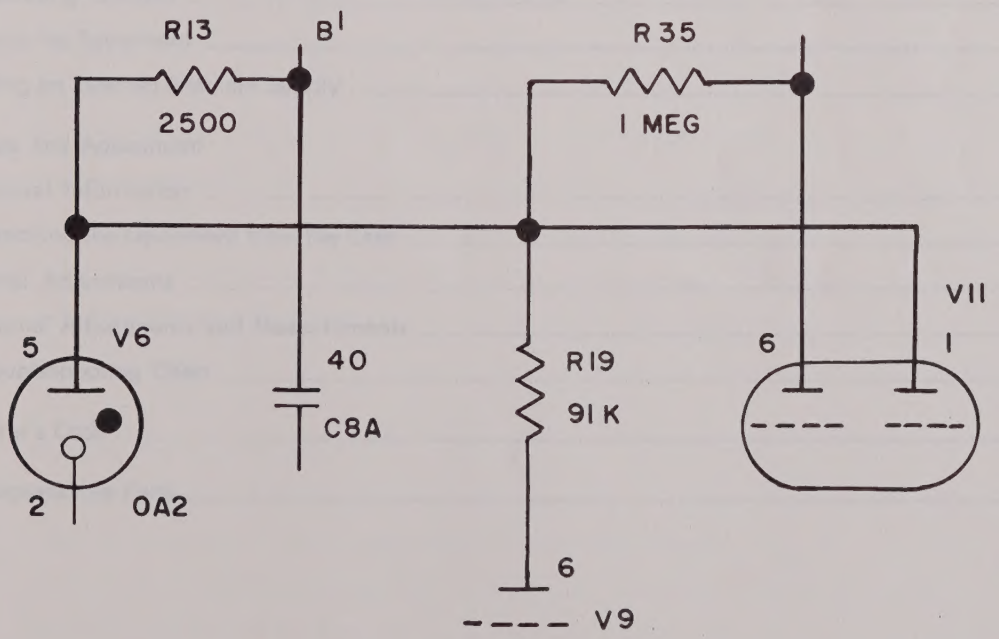
Page 30. Change the part number of relay K3 from B-02602 to B-02604.

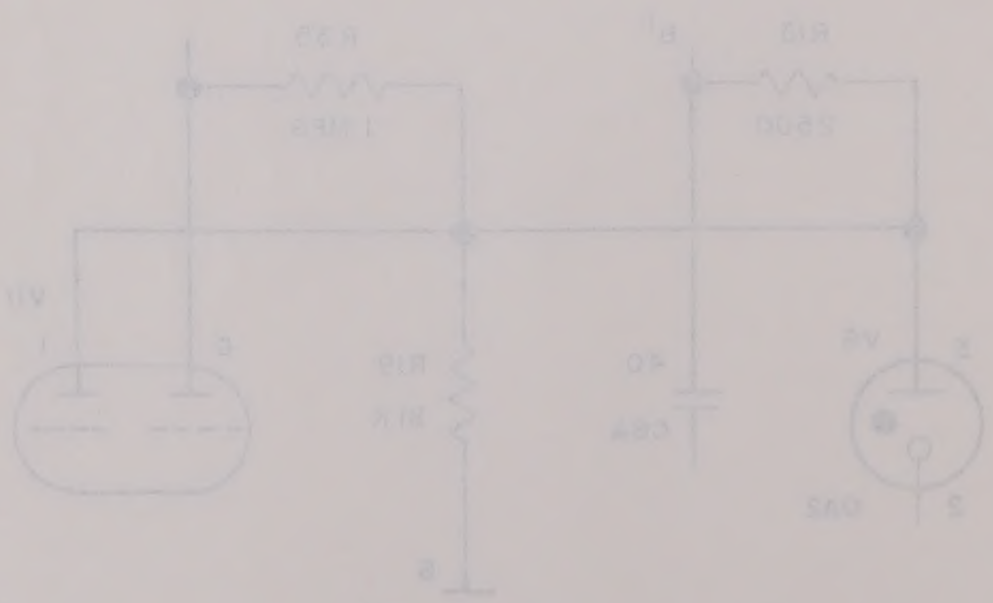
Page 32. The value of R60 was changed in equipment with serial numbers 559,562,573,574,576,583,585,591,592,595,596,597, 601 and higher. Either a 127 ohm resistor, part number A-01116-211 or a 110 ohm resistor, part number A-01116-205 may be used depending upon the coil of relay K3.

Page 33. The value of R61 was changed in equipment with serial numbers 559,562,573,574,576,583,585,591,592,595,596,597, 601 and higher. Either a 49.9 ohm resistor, part number A-01117-168 or a 43.2 ohm resistor, part number A-01117-162 may be used depending upon the coil of relay K3.

Page 37-38. In units with serial numbers 559,562,573,574,576,583,585,591, 592,595,596,597, 601 and higher, the value of R60 may be either 110 or 127 ohms and the value of R61 may be either 43.2 or 49.9 ohms.

In all units the plate circuits of V9 and V11 are shown incorrectly on the schematic diagram. Change the schematic to the configuration shown below.





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SPECIFICATIONS

BEAM SUPPLY

Voltage	200 to 4000 v dc
Regulation	0.01%
Ripple	Less than 3 mv
Current	150 ma maximum (360 watts maximum)

REFLECTOR SUPPLY

Voltage	0 to 1000 v dc
Regulation	0.01%
Ripple	Less than 3 mv

CONTROL GRID SUPPLY

Positive Voltage	0 to 150 v dc, 25 K ohm source
Off position	Connected to beam
Negative voltage	0 to —300 v dc
Regulation	0.01% (negative supply)
Ripple	Less than 5 mv

FILAMENT SUPPLY

Voltage	6.3 v ac
Current	4 amperes maximum
External	Through terminal board

MODULATION

Internal sine wave	Line frequency, 0 to 200 V p-p
Internal square wave	200 to 2000 cps, 0 to 200 V p-p
Internal sawtooth	40 to 400 cps, 0 to 200 V p-p
External direct	Direct to reflector, 270 K ohms impedance
External amplified	High impedance, gain 18 X

PHYSICAL CHARACTERISTICS

Size	12" x 20" x 17"
Weight	125 pounds

INPUT POWER REQUIREMENTS

105-125 V ac, 50/60 cps	875 watts maximum

INTRODUCTION

Figure 1. narda Microline **Model 62A1 Universal Klystron Power Supply**

The narda Microline Model 62A1 Universal Klystron Power Supply, figure 1, is a primary power source for the majority of currently available laboratory klystrons and many small magnetrons. It may also be used to operate several types of BWO tubes. The unit is supplied in a cabinet for bench use, but may be rack mounted if desired since it is constructed on a standard 10½ x 19 inch rack panel. Weighing only 125 pounds including the case, the 62A1 is the lightest and most compact klystron supply in the universal class.

Beam voltage is continuously adjustable over its entire range without switching. The beam voltmeter is automatically switched to a higher range as the voltage is increased. Selecting beam overload relay sensitivity automatically sets the beam current meter range for maximum useful full scale reading.

Sawtooth, sine wave, and square wave modulation may be applied to the klystron reflector from either the internal modulator or an external source. External modulation may be applied directly to the reflector from a high level source or from a low level source using the internal modulator amplifier.

Klystron output connectors and a-c accessory outlets are available on both front and rear of the 62A1. This permits convenient rack cabinet installation using the rear connector, or both outputs may be used for simultaneous operation of two klystrons.

The internal filament supply is rated for 6.3 volts at 4 amperes. It may be disabled conveniently and replaced by an external filament supply, such as the narda Microline 62A2, if desired. Major test points and adjustments are accessible without removing the instrument from the case.

THEORY OF OPERATION

KLYSTRON VOLTAGE RELATIONSHIPS

Reflex klystrons used in the laboratory usually have the following power requirements: (1) Heater or filament, (2) Beam (also called resonator), (3) Reflector (also called repeller), (4) Control grid (also called focus electrode.). Some klystrons omit the control grid and a few omit the reflector. Manufacturer's tube data should always be consulted before setting up for use with any power supply.

The following may vary with certain tubes, but represents general practice in klystron operation.

The body or cavity structure of the klystron is operated at ground potential to permit direct connection to the waveguide setup. Since the cavity must be positive with respect to the cathode, the cathode, or BEAM potential, is negative to ground. The cathode is the reference for all other potentials in the klystron supply. One side of the heater winding is connected to the cathode, usually at the tube socket or in the output cable. Some tubes have this connection inside the base and care must be taken to insure that cable wiring corresponds to internal tube wiring. Grid voltage is applied with respect to the cathode and may be positive, negative or zero, depending on the tube characteristics. Negative grid tube operation should be started at maximum rated negative voltage and the bias carefully reduced to the rated operating point. Positive grid tubes are started at zero voltage and potential is increased until rated conditions are achieved. Reflector potential is negative with respect to the cathode as well as to the cavity. The reflector does not draw current and its power supply frequently has a relatively high internal impedance. Tube damage is almost certain if the reflector is allowed to go positive with respect to the cathode structure, and a protective diode is included in the 62A1 to prevent this condition.

Klystrons are normally modulated on the reflector. If reflector potential is varied with respect to the cathode, the klystron may be swept from a non-oscillating condition into its mode and out again, giving a direct plot of power output variation with reflector voltage. This facilitates klystron adjustment and setup tuning. Reflex klystron frequency also varies with reflector voltage, and frequency modulation can be obtained with either sawtooth or sine wave modulation from the power supply. Square wave modulation is used to switch the klystron into and out of its mode, keying output power on and off at the modulating rate.

FUNCTIONAL DESCRIPTION

A functional block diagram of the Model 62A1 Universal Klystron Power Supply is shown in figure 2. The beam supply is continuously variable between —200 and —4000 volts with respect to ground. Reflector potential is continuously adjustable from 0 to —1000 volts with respect to the beam voltage. The negative reflector supply also supplies negative grid voltage which is continuously adjustable from 0 to —300 volts. A supply is also included in the reflector deck to furnish positive grid potential variable between 0 and +150 volts. The negative beam, reflector, and grid supplies are regulated to 0.01% or less with a 10% line change because the klystron frequency and power output are both very sensitive to variations in these potentials. The positive supply is not so critical and is regulated to approximately 1%, no load.

The internal klystron filament supply is floating and connection to the beam is normally made at the klystron socket or in the output cable. A jumper board on the rear of the chassis permits disabling the internal supply and inserting an external supply. The narda Microline Model 62A2 DC Klystron Filament Supply is recommended for stable, regulated d-c filament power.

The modulator has a sawtooth generator as its basic frequency control. Its output is used directly for sawtooth modulation of the klystron reflector, and for driving an internal square wave generator when square wave modulation is required. Sawtooth frequency range is 40 to 400 cps for klystron mode observation and other applications where relatively slow sweeps are needed. Square wave frequency range is 200 to 2000 cps to include the common modulating frequencies used in tuned measuring instruments, such as SWR indicators which normally operate at 1000 cps. The sawtooth oscillator may be synchronized from an external source. The modulator's wide band output amplifier is used with the internal waveform generator for self-contained modulation and may be used for modulation with a low level external signal source. When a high level external modulating source is employed, the internal amplifier may be switched out of the circuit.

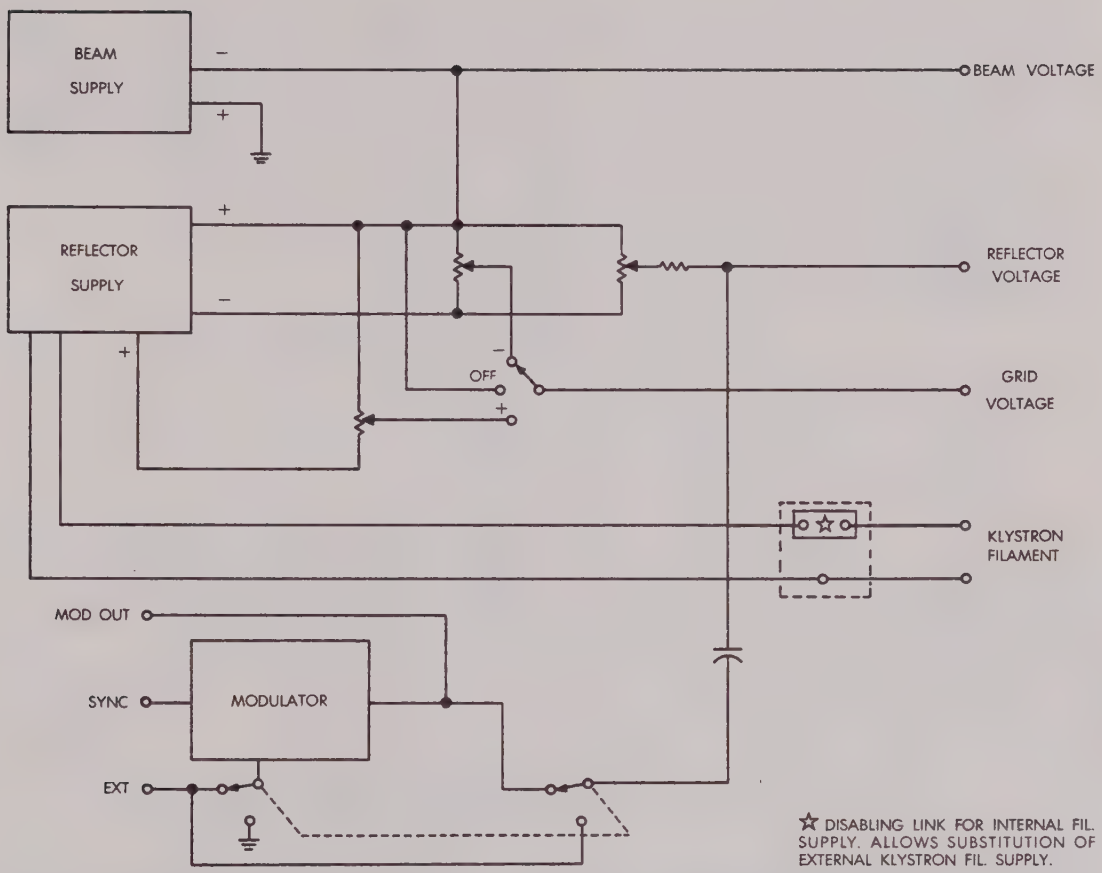


Figure 2. narda Microline **Model 62A1 Functional Block Diagram**

CIRCUIT DESCRIPTION

The 62A1 Universal Klystron Power Supply has three sections: reflector deck, modulator, and beam supply. The latter includes the switching and control circuits. Simplified block diagrams are keyed into the brief circuit descriptions which follow. Circuit details are provided on the schematic diagrams at the back of this handbook.

REFLECTOR DECK

The reflector deck, figure 3, provides klystron reflector potential, positive and negative grid voltage, and filament power for the klystron.

Two 6AX4 half-wave rectifier tubes (V101 and V102) in a full-wave voltage doubler circuit supply the voltage regulator. The conventional electronic regulator uses a 6AQ5 (V103) series gate tube, a 12AX7 (V104) d-c amplifier, and a 5651 (V105) voltage reference tube. The 1000 volt output is regulated within 0.01% for 10% line changes with output ripple of less than 3 millivolts. Reflector potential is adjusted by a 10-turn potentiometer (R116) across the regulator output. A 6X4 protective diode (V107) between the output connection to the reflector and the beam supply prevents any positive excursion with respect to the klystron cathode.

Power transformer T101 supplies the klystron filament with 6.3 volts ac at a maximum current of 4 amperes. An electrostatic shield between the primary and all secondaries reduces capacitive coupling from the line to the klystron circuits which might result in output variations. One transformer winding provides the 6AQ5 (V103) screen voltage and

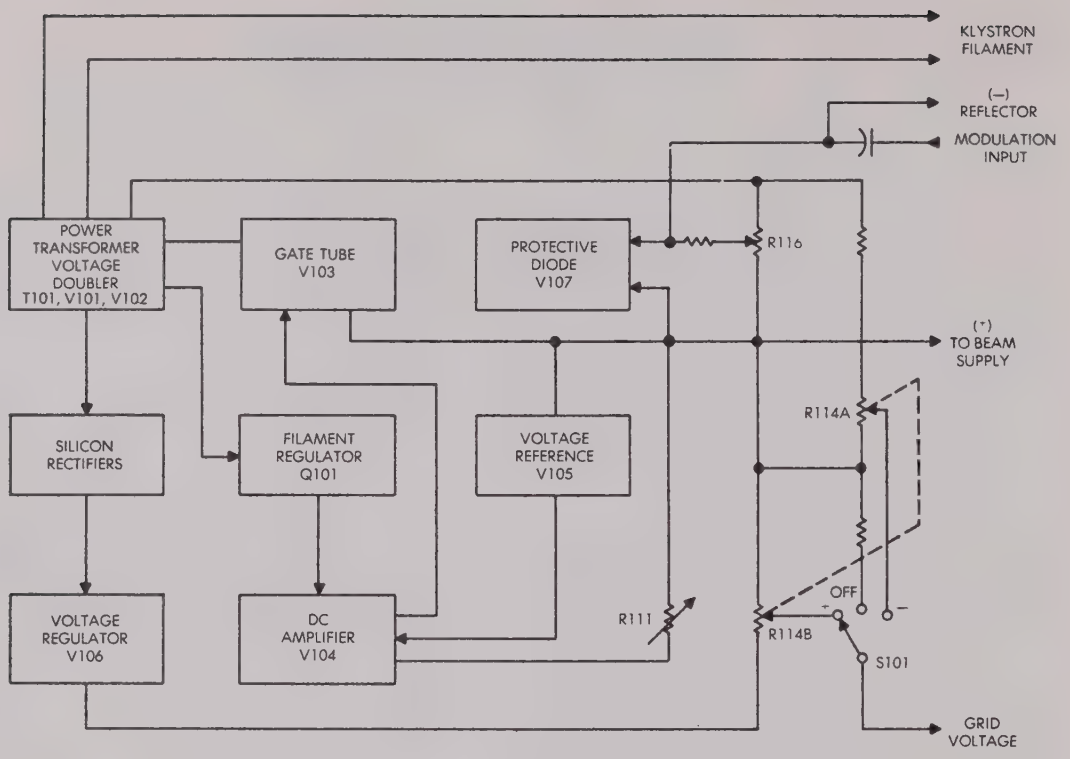


Figure 3. Reflector Deck, Functional Block Diagram

supplies the OA2 regulator (V106) for the positive grid supply. R114 is a dual potentiometer which controls both positive and negative grid voltages; S101 selects positive, negative or zero grid voltage for the klystron.

Heater voltage to d-c amplifier V104 is regulated by transistor Q101. Operation is described below.

Filament Regulator

The filament regulator, figure 4, stabilizes against line changes. Operation is similar to the clipping action of a Zener diode though it tends more to regulate current than absolute voltage. Full-wave rectified voltage from the bridge is applied to the base feed network (R128-CR109-CR110), through the heater load-transistor-sensing resistor (R129 and R130) circuit and through compensating resistor (R120) to the sensing resistor.

Voltage increases in a negative direction starting from zero. CR109 and CR110 are silicon rectifiers connected in the forward direction for a negative voltage, but they do not conduct until their threshold voltage is exceeded. The available voltage is therefore applied to the transistor base through R128, turning it fully on. Current increases in the heater load and sensing resistor combination as the supply voltage increases. Voltage drops are essentially divided between the heater load and the sensing resistor. When the voltage across the sensing resistor reaches the threshold of the silicon rectifiers, they go into conduction, limiting the voltage to the forward voltage drop. At low current, the forward drop is very nearly constant for a considerable range of input voltage; thus the base is effectively supplied with a reference. Further increase of the supply voltage tends to increase the voltage drop in the sensing resistor and bias the transistor off. Through this inverse feedback, transistor current is suddenly limited to a constant value as soon as reference action begins. There is a slight decrease in transistor current as the peak of the applied voltage approaches because of the current through R64, which is relatively independent of transistor current. This permits close control of the RMS value of the load voltage.

If a sine wave is clipped at a constant level, the RMS value of the clipped waveform will increase as the amplitude before clipping is increased. The amount of increase depends upon the degree of clipping used. In the 62A1 regulator, clipping level is depressed slightly at the input voltage peak. As input voltage increases, the depression increases, with the amount of depression controlled by the ratio

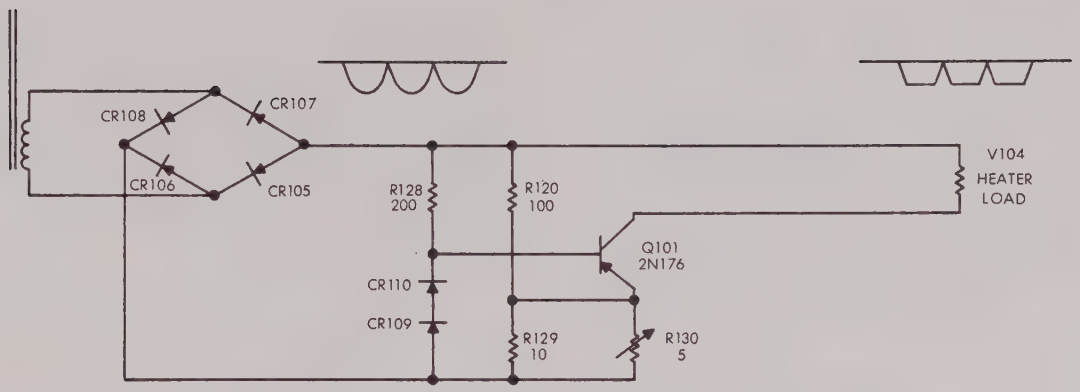


Figure 4. Filament Regulator, Schematic Diagram

of load current to compensation circuit current. R120 determines the RMS compensation required to stabilize the regulator d-c amplifiers against line changes and give reliable 0.01% beam regulation. The heater voltage waveform is essentially a clipped full-wave rectified sine wave.

MODULATOR

The four tube modulator consists of a sawtooth generator, flip-flop circuit, and two stages of broadband amplification. The front panel MODULATOR switch (S201) selects the type of internal modulation and switches the internal amplifier in or out when external modulation is used.

Figure 5 is a simplified functional block diagram and figure 27 a schematic diagram of the modulator.

Circuit Operation

A 6D4 thyratron (V201) serves as the discharge tube in the plate circuit of the pentode side (V202A) of a 6U8. The pentode is a constant current source, giving linear voltage change with time across the sawtooth charging capacitor. When the capacitor voltage reaches a point set by its bias, the 6D4 (V201) fires, discharging the capacitor and completing the cycle. When sawtooth modulation is used, sawtooth rate is adjustable from 40 to 400 cps by varying FREQUENCY control R204, in V202A charging circuit. When square wave modulation is used, the sawtooth rate is increased to 400 to 4000 cps to trigger a flip-flop circuit and give a square wave at half the input frequency, or 200 to 2000 cps.

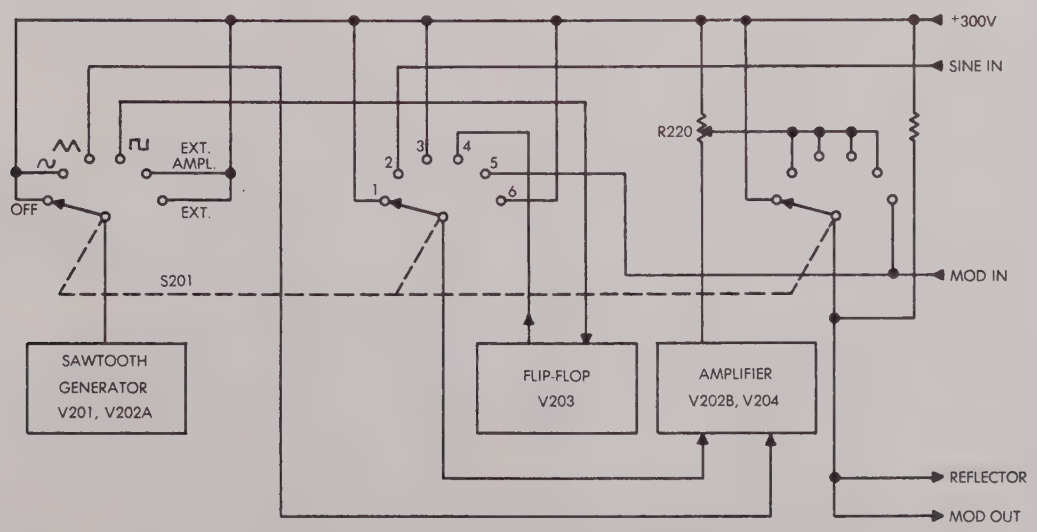


Figure 5. Modulator, Functional Block Diagram

The FREQUENCY control (R204) has a 10% CCW taper to spread the upper end of the modulator frequency range and facilitate adjustment at 1000 cps where 30 to 50 cps bandwidth is frequently encountered in associated measuring equipment. R205 adjusts the bias for V201 and controls the amplitude of the sawtooth. R215 sets the low frequency end point of the sawtooth generator. Actual adjustment range is determined by the ratio of the maximum resistance of R204 (FREQUENCY) to R203 in the cathode circuit. After the frequency range for one waveform has been set, the other is obtained by switching the charging capacitor.

The two stage output amplifier consists of the triode section of the 6U8 (V202B) and a 6CL6 pentode output state (V204). Inverse feedback is used to insure a wide linear range. The AMPLITUDE control (R220) in V204 plate circuit minimizes frequency response changes with changes in control setting.

Maximum rated output from the modulator is 200 volts peak-to-peak for all waveforms. All modulators are set for maximum linear output voltage at the factory and the actual maximum output amplitude on a unit may exceed 200 volts. For sine wave operation, the signal is obtained from a potentiometer across one of the heater windings and is not regulated. As the line voltage varies, sine wave output will also vary. This level is set for maximum linear output at the factory with 125 volt line. If the line voltage falls to 105 volts, the lower limit of rated 62A1 operation, sine wave output amplitude may fall slightly below 200 volts on some units.

Functional Operation

In position 1 (OFF) of the MODULATOR switch (S201) the modulator is inoperative and the output lead is grounded.

In position 2 (~) of S201, a sine wave from a heater winding is applied to the input of the two stage amplifier. Level of the sine wave input to the modulator chassis is controlled by R63, MOD CAL, on the rear of the main chassis. Since the sine wave signal is obtained from a transformer winding, any distortion appearing in the line voltage will also appear in the sine wave modulation.

In position 3 (⩘) of S101, output from the sawtooth generator is applied to the output amplifier.

Position 4 (⊓) switches the flip-flop output to the amplifier input, changes the sawtooth charging capacitor, and applies the sawtooth output to the flip-flop input. R216 controls the amlitude of the square wave applied to the amplifier input.

In position 5 (AMPL. EXT.) of S201, the sawtooth generator is inoperative and the amplifier input is connected to the MOD IN jack on the front panel. This permits a low level external source to be used for modulating the klystron. Maximum input level is approximately 14 volts peak-to-peak for undistorted modulator output. Note that the modulator AMPLITUDE control is in the plate circuit of the output stage. Excessive input signal which causes overdriving in the amplifier cannot be reduced with the AMPLITUDE control and this precaution should be observed when using the AMPL. EXT. position.

In position 6 (EXT.) of S201, the modulator is completely by-passed and the signal from the MOD IN jack is applied to the reflector through blocking capacitors. Since there is no amplification in this position, the external modulating source must be capable of supplying the necessary waveform voltage.

Modulation may be monitored at all times at the front panel MOD OUT jack, and internal voltages are available there for external use. There is no internal blocking capacitor in the MOD OUT circuit because the modulator circuit is "upside down" with the positive side of the power supply grounded. If a coupling capacitor is required, it can be added externally with a value appropriate for the frequency and waveform involved. If a d-c path is present in the external circuit connected to the MOD OUT jack, it must have a resistance of 10,000 ohms or more since the external circuit shunts the BEAM MILLIAMPERES panel meter.

CAUTION

The MOD OUT jack should never be grounded with modulator amplitude advanced because this puts full modulator output across the BEAM MILLIAMPERES meter and may damage it.

Modulator frequency may be synchronized by application of an external signal to the SYNC jack on the panel.

BEAM SUPPLY

The beam supply includes all switching and control circuits for the 62A1 as well as the main power supply for the klystron. A block diagram is shown in figure 6.

Beam Voltage

Voltage for the filter and regulator circuits is supplied by a full-wave voltage doubler using 866A mercury vapor rectifiers (V1 and V2). The main beam transformer (T3) provides the step-up needed for the voltage doubler Primary voltage is controlled by variable transformer T2, the BEAM control on the front panel. Overload relay K3 is in series with the positive power supply lead at the plates of the series gate

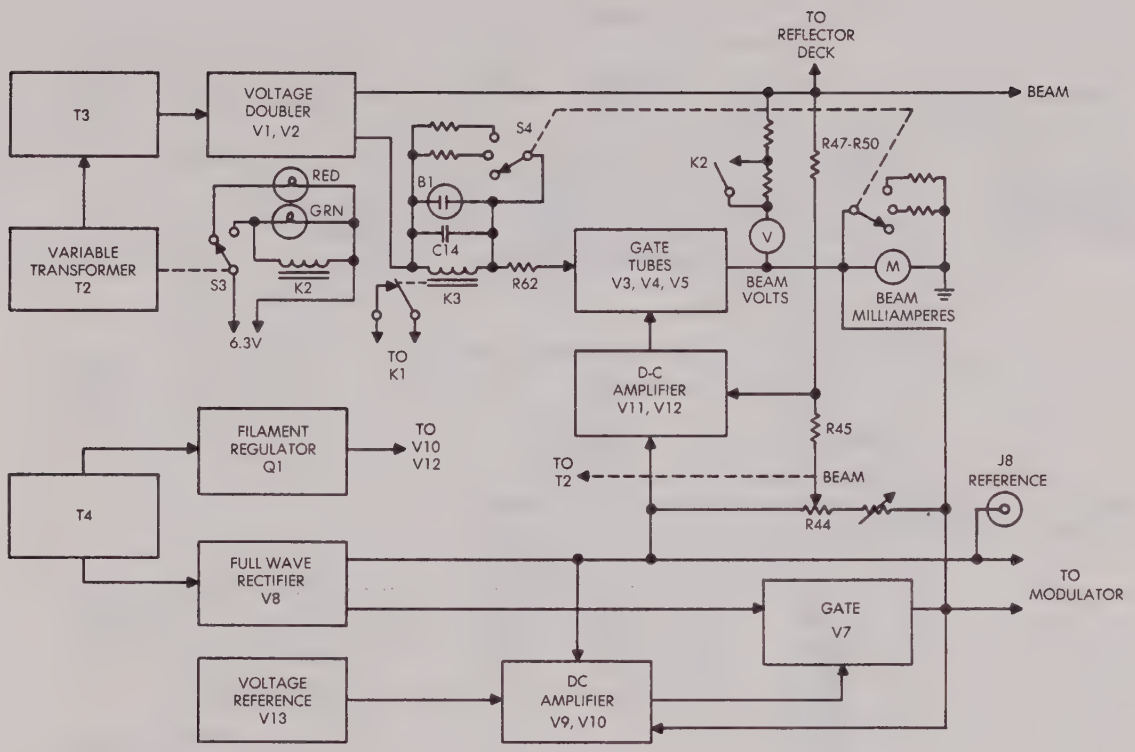


Figure 6. Beam Supply, Functional Block Diagram

tubes (V3, V4, and V5). R62, C14, and B1 (the NE-2 neon lamp) protect the overload relay coil from excessive voltage in the event of arc-over or short circuit at the beam output. Overload current ranges are selected by the OVERLOAD switch (S4) on the panel which adds shunt resistors to the coil circuit as required. Contacts of K3 are normally closed and break the supply voltage to the beam supply control relay (K1) when the preset overload current level is exceeded.

Three 6CD6GA series gate tubes (V3, V4, V5) connected in parallel provide enough current capacity for rated beam operation over the 62A1 range. Screen voltage for the gate tubes is provided by a separate supply. To insure immediate cutoff when the overload relay is tripped, one set of contacts on K1 removes the screen voltage when overload operation de-energizes K1. 12AX7's (V11 and V12) are used in the balanced d-c amplifier; the heater of V12, the input stage, is regulated against line voltage changes. Error signal for the beam d-c amplifier is obtained from a form of bridge circuit which compares the reference supply with a portion of the beam output voltage. Actual control of the beam output voltage depends on the position of R44 which is ganged to variable transformer T2, the BEAM control. Voltage at the output terminal of R44 is compared to the beam voltage through a stable resistive divider (R45 and R47-R48-R49-R50). These wirewound, low temperature coefficient resistors maintain stable beam output voltage. Since the divider ratio is unchanged over the entire beam range of the 62A1, uniform gain and regulation are obtained at all voltages.

The BEAM MILLIAMPERES meter is in series with the positive ground return of the beam supply. Three meter ranges are available which are changed automatically with selection of overload current. A 25 ma full scale range is used with the 25 ma overload trip, a 100 ma range with the 75 ma trip, and 200 ma range with the 150 ma trip. The BEAM VOLTS meter is connected from the output beam voltage lead to the positive ground return of the regulator. This meter has two ranges, 1000 volts full scale and 5000 volts full scale. When the BEAM control is between 200 and about 900 volts, the 1000 volt scale is used. As the beam voltage is increased to about 900 volts, a cam on the variable transformer operates switch S3 and automatically changes the voltmeter range to 5000 volts by the operation of the voltmeter switching relay, K2. S3 also controls the scale indicator lights

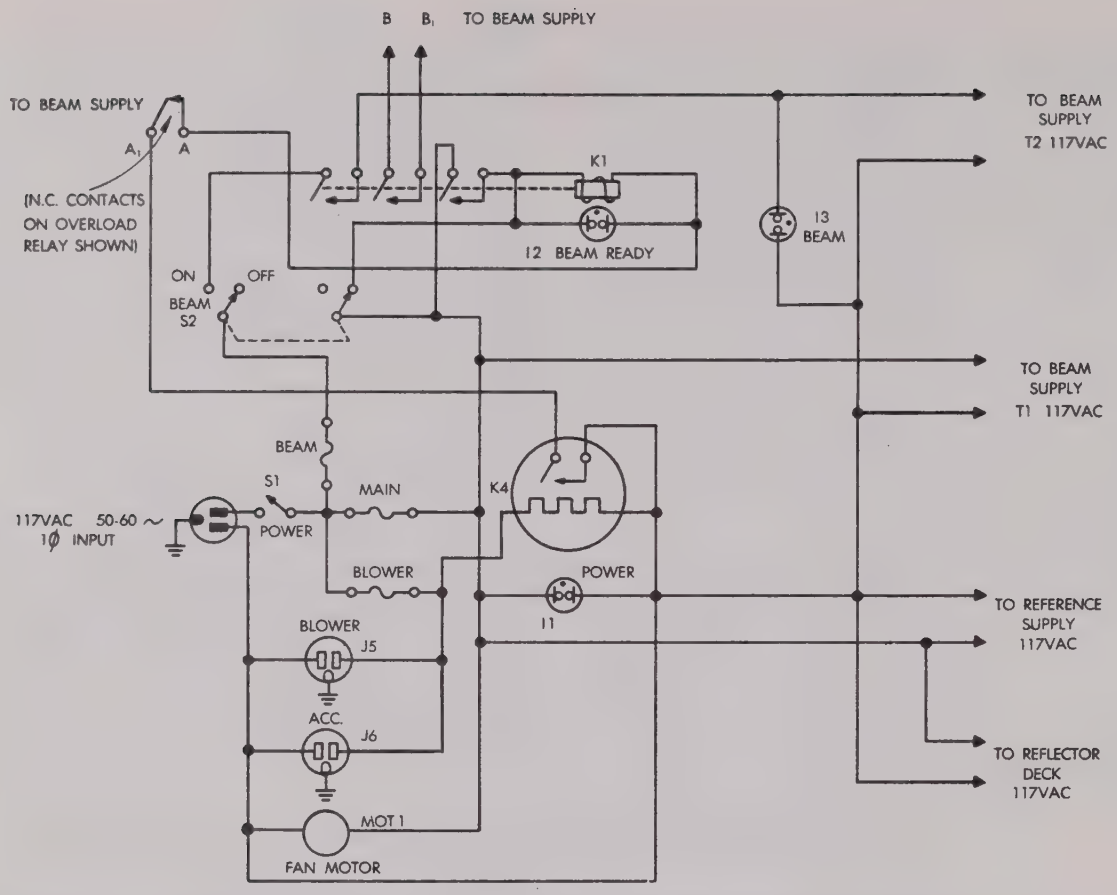


Figure 7. Power and Switching Circuits, Simplified Schematic Diagram

on either side of the BEAM VOLTS meter which show the scale in use by their color. The dual range voltmeter eliminates the need for mechanical voltage indicators on the BEAM control and gives reliable calibration at all times. Approximate beam voltage is indicated by calibration marks around the BEAM control.

Reference Voltage

Regulated reference voltage for the beam supply regulator is obtained from a special reference supply. A 5Y3GTA full-wave rectifier (V6) delivers voltage to the 6AQ5 gate tube (V7) connected in the grounded positive return of the supply. Screen voltage for the 6AQ5 (V7) is obtained from the same source that feeds the 6CD6GA gate tube screens in the beam regulator. A 5651 tube (V13) is the primary reference for the supply. The balanced d-c amplifier (V9 and V10) is similar to that in the beam regulator, with the input stage (V10) heater voltage regulated. The reference supply output is used in the beam regulator for voltage comparison and also for plate voltage in the modulator. Output voltage from the reference supply is about 300 volts and is measured at the REF jack, J8, on the rear of the chassis.

Heater voltage to d-c amplifiers V10 and V12 is regulated by Q1 in a manner similar to that described for Q101 in the reflector deck. However, a capacitor has been added so this filament regulator operates more as a d-c regulator.

Power Supply and Switching Circuits

Figure 7 is a simplified schematic diagram of the power and switching circuits. Operation of POWER switch S1 applies the line voltage to the front panel BLOWER socket, ACC socket on the rear of the chassis, time delay relay K4, POWER indicator light I1, 866A filament transformer T1, reference supply, and reflector deck. Filament power to the klystron is available from the reflector deck as soon as the POWER switch is turned on. After approximately 60 seconds, time delay relay K4 operates, energizing K1 and turning on BEAM READY light, I2. K1 completes the screen circuit to the 6CD6 gate tubes, closes its own holding circuit, and connects the beam supply input to BEAM switch S2. Beam voltage may now be ap-

plied to the klystron by turning on the BEAM switch which completes the circuit to the beam supply and turns on BEAM light I3. If an overload occurs, overload relay K3 contacts break the circuit to the coil of K1 which opens, removing line voltage from the beam supply, turning off the BEAM and BEAM READY lights, and removing screen voltage from the 6CD6 gate tubes. Throwing BEAM switch S2 to the off position completes the circuit to K1, resetting it and lighting the BEAM READY indicator. Beam voltage may now be reapplied by turning on the BEAM switch.

Klystron Protection

If the blower or accessory circuits of the 62A1 should be loaded beyond the capacity of the BLOWER fuse, the fuse will open and power will be removed from time delay relay K4. This interrupts the beam circuit by opening K1, preventing klystron damage which might be caused by loss of blower cooling.

OPERATION

INSTALLATION

This equipment has been calibrated and tested before shipment and is ready for immediate use.

CAUTION

This unit uses mercury vapor rectifier tubes. During shipment mercury is scattered throughout the tube envelopes and internal arcing may occur if high voltage is applied immediately. To prevent possible arcing, connect the equipment to the 117 volt line, turn the POWER switch on and allow it to warm up for 15 minutes. This will redistribute the mercury in the tubes. This procedure need not be repeated unless the equipment is moved in such a way that the mercury is disturbed. Operate the 62A1 only in the normal upright position.

The 62A1 is supplied in a cabinet for bench use. Four ventilation holes in the bottom of the case must be clear during operation. At least five inches of space must be provided at the rear of the unit for proper air circulation and cooling.

The 62A1 will operate with line voltage between 105 and 125 volts, 50 to 60 cps. Approximately 875 watts are required under maximum load conditions. Capacitor input filters are used in the 62A1 and, as such, are "peak operating" devices which require an input sine wave reasonably free of distortion. If a line voltage regulator is used with the 62A1, it must be a type which does not introduce appreciable peak clipping of the line waveform.

The equipment may be mounted directly in a standard rack after removing it from its case. (See page 18 for instructions.) The panel is a standard 10½ inch height and the unit requires 15½ inches behind the panel.

CAUTION

Removal of this unit from its cabinet exposes high voltage points. When rack mounting, use an enclosed cabinet and make provisions to protect personnel.

OPERATING CONTROLS

Front panel controls function as follows. See figure 8A.

1	**BEAM**	Controls beam voltage. Automatically switches range of BEAM VOLTS meter.
2	**BEAM VOLTS**	Meter monitors beam voltage. Scale in use is indicated by lamps flanking meter.
3	**FREQUENCY**	Controls internal square wave and sawtooth modulation frequencies.
4	**MODULATOR**	Selects internal sine wave, square wave, and sawtooth modulation; external modulation may be amplified or applied directly; allows c-w operation without modulation.
5	**AMPLITUDE**	Controls level of internal and external amplified modulation.
6	**BEAM MILLIAMPERES**	Meter indicates beam current.
7	**GRID SELECT**	Selects zero, negative or positive bias for klystron control grid.
8	**OVERLOAD**	Selects beam current overload point. Changes range of BEAM MILLIAMPERES meter.
9	**REFLECTOR**	Controls level of klystron reflector voltage.
10	**OUTPUT**	Connector supplies operating voltages and modulation to klystron.
11	**BLOWER**	A-c outlet for blower or external accessory. Controlled by POWER switch.
12	**BEAM**	Switch applies beam voltage. Must be reactivated to reset overload relay and reapply beam voltage if overload occurs.

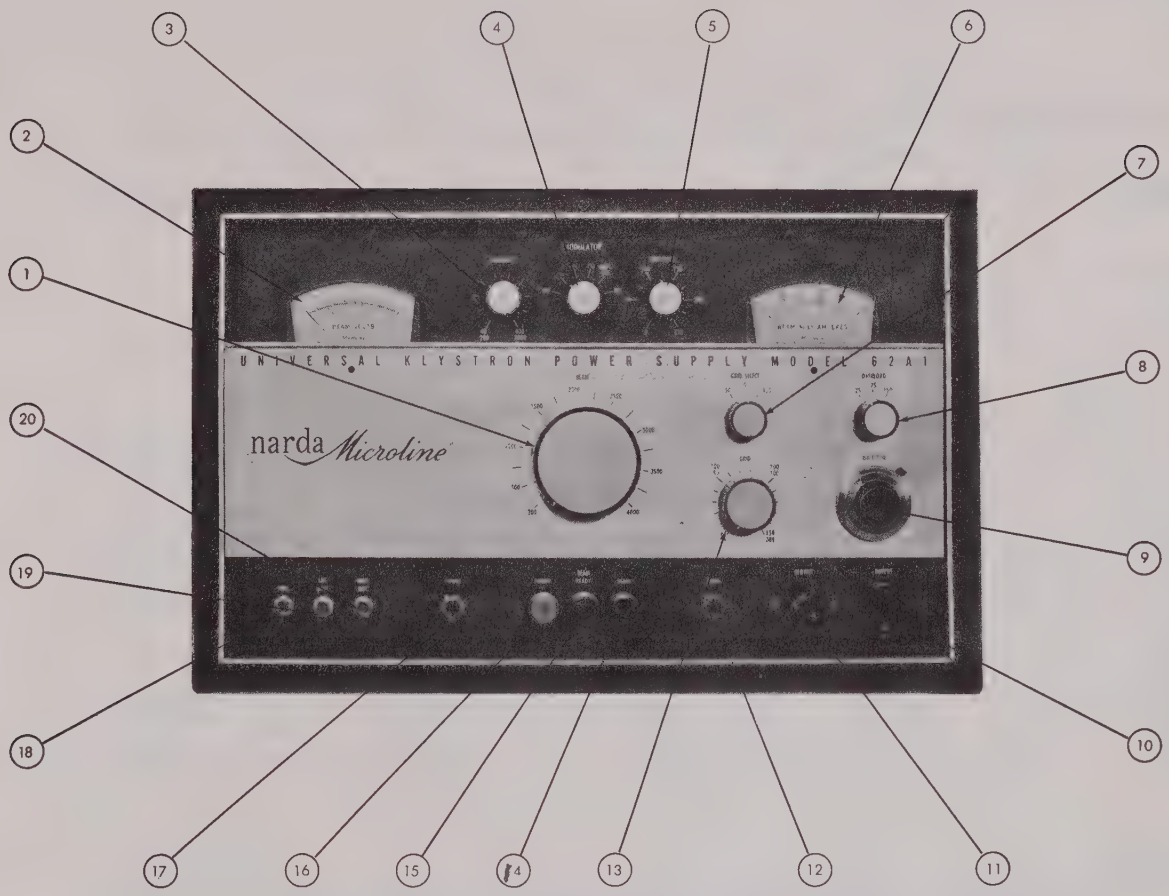


Figure 8A. Operating Controls, Front Panel

13 GRID	Controls level of positive and negative bias voltages.
14 BEAM	Pilot lamp indicates application of beam voltage.
15 BEAM READY	Pilot lamp indicates readiness of beam supply. Extinguishes when overload relay opens.
16 POWER	Pilot lamp indicates application of line voltage.
17 POWER	Switch controls application of primary a-c power.
18 SYNC.	Jack for insertion of sync to modulator oscillator.
19 EXT. MOD.	Jack for external modulation input.
20 MOD. OUT.	Jack couples modulation out for external use.

OPERATING CONTROLS (Continued)

Rear chassis apron controls and test points. See figure 8B.

1	**KLYSTRON FIL. JUMPER**	Completes internal supply wiring. Allows substitution of external klystron filament supply.
2	**OUTPUT**	Connector wired in parallel with panel OUTPUT connector. Allows operation of second klystron. Used for interconnection when unit is rack mounted.
3	**MOD. CAL.**	Adjusts level of line-frequency sine wave to input of modulator amplifier.
4	**COM.**	Common test point for all rear chassis apron measurements.
5	**REF.**	Test point for measurement of reference supply voltage.
6	**BEAM RANGE**	Adjusts low end limit of beam voltage range.
7	**GATE BAL.**	Test points for voltage measurement. Used to check balance of gate tube currents.
8	**BEAM ADJ.**	Adjusts high end limit of beam voltage range.
9	**BLOWER**	Fuse protects both a-c outlets (front panel and rear chassis apron). Disables thermal relay controlling beam voltage when open.
10	**BEAM**	Fuse in transformer primary of beam supply.
11	**MAIN**	Fuse in incoming a-c line. Protects against overload.
12	**LINE CORD**	Standard (2-wire plus ground) line cord. For connection to 117 vac source.
13	**ACC.**	Accessory a-c socket wired in parallel with BLOWER socket on front panel. Controlled by POWER switch.
14	**-1000 V REFLECTOR SUPPLY**	Jack for application to the 62D1 Klystron adapter.

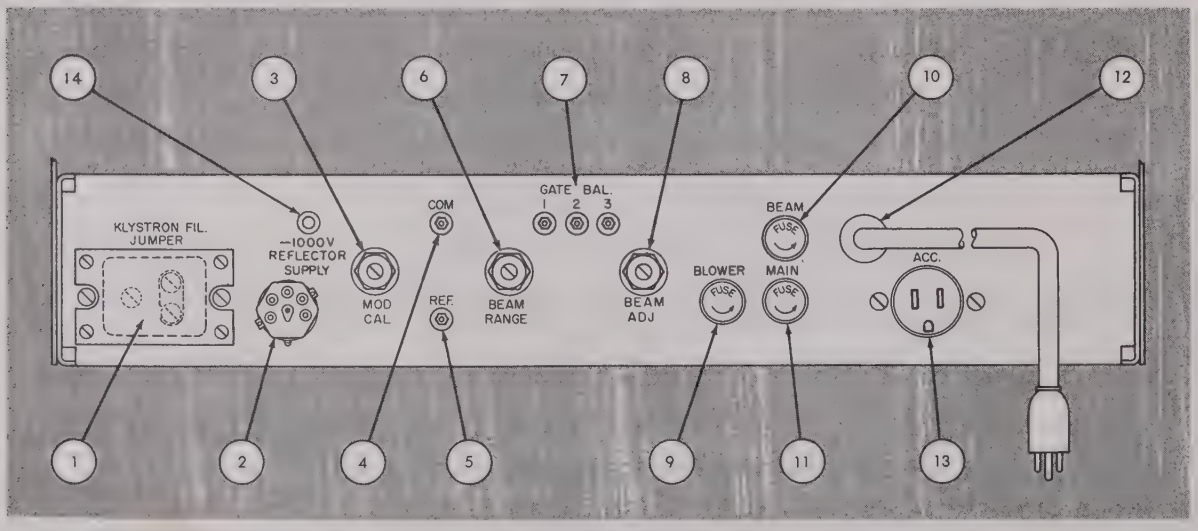


Figure 8B. Operating Controls, Rear Chassis Apron

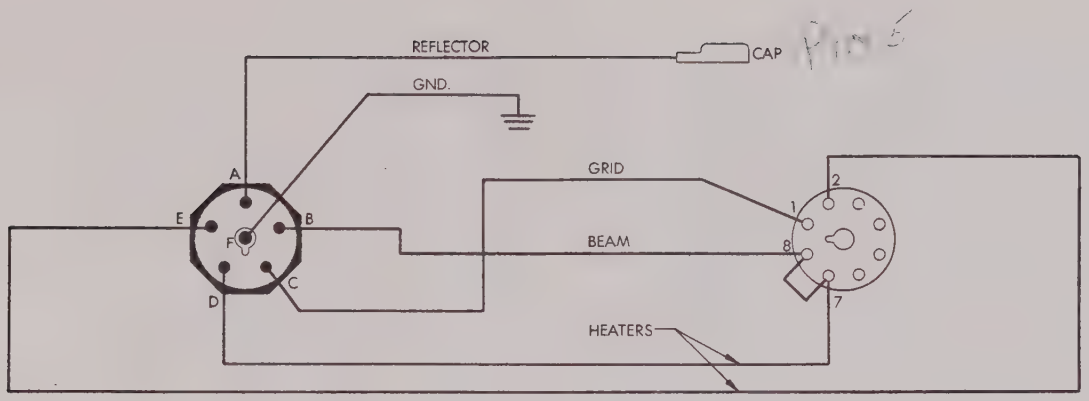


Figure 9. Typical Cable Assembly

Klystron Connecting Cable

A typical cable assembly is shown in figure 9. The ground lead is connected to the klystron body or frame. No klystron cable is furnished with the 62A1 because of the wide voltage range of the equipment. A cable with the internal insulation required for 4000 volt operation would be unnecessarily bulky when used with a small 600 volt tube. Two plugs which mate with the OUTPUT connectors are supplied with each 62A1 for convenience in making up klystron cables to individual requirements. Additional connectors are available from most parts distributors. The connectors are Winchester Electronics type PM6P-LSH.

USING THE EQUIPMENT

CAUTION

The modulator plug, P201, must be connected to Jack, J9, on the main chassis for beam regulation.

After connecting the klystron cable to either of the OUTPUT connectors, set GRID and REFLECTOR controls to approximate settings (see klystron manufacturer's data sheet), turn the POWER switch on and wait approximately one minute for the time delay relay to operate. This is sufficient warmup time for most klystrons, but consult manufacturer's recommendations for each type before use. If a blower is required for the klystron, be sure it is connected to the BLOWER socket or the ACC socket on the rear of the chassis. The POWER indicator will light when the switch is thrown. ALL VOLTAGES EXCEPT THE BEAM ARE APPLIED TO THE KLYSTRON WHEN THE POWER SWITCH IS TURNED ON.

After approximately one minute, time delay relay K4 will close, lighting the BEAM READY indicator and operating K1. The unit is now ready for application of beam voltage to the klystron.

CAUTION

Be sure the GRID control is set for a bias condition that will prevent excessive klystron dissipation when beam voltage is applied.

Set the OVERLOAD switch to the desired overload current point, turn the BEAM control to 200 volts, and turn the BEAM switch on. The BEAM indicator will light and 200 volts will be shown on the BEAM VOLTS meter. Advance the BEAM control for the desired beam voltage, and adjust the GRID control for desired beam current as indicated on the BEAM MILLIAMPERES meter. Further detailed adjustment procedure will depend somewhat on the particular klystron and setup in use. (See the following general setup discussion for additional information.)

If the preset overload current point is exceeded, the overload relay will trip, removing beam voltage and turning off the BEAM and BEAM READY indicators. To reset the equipment, throw the BEAM switch off, which lights the BEAM READY indicators and resets the main control relay. When the BEAM switch is returned to the on position, the BEAM indicator will light and beam voltage will be reapplied to the klystron.

If two klystrons are parallel-connected to the 62A1, be certain that the heater-to-beam jumpers are compatible in both cables. With both klystrons connected, the REFLECTOR setting may have to be a compromise for the two tubes since they may have slightly different reflector characteristics. Only tubes which are very nearly alike can be operated in this arrangement. If they are not close enough, separate reflector adjustments must be used. Remember that with two tubes, the BEAM MILLIAMPERES meter will read the sum of both beam currents.

The modulator can be used to considerable advantage in setting up the klystron and is essential in measurements where associated instruments operate on the signal modulation, such as in VSWR measurements. The following paragraphs contain general information which may be used with variations as required by the particular klystron in use.

Reflex Klystron Operation

A general understanding of klystron operation is helpful in initial adjustments in the setup. Figure 10A shows a schematic view of a typical reflex klystron. Voltage relationships for the tube were given under THEORY OF OPERATION. With the beam voltage applied, current will flow from the cathode to the cavity, with the amount of current controlled by the grid. The cavity is a resonant structure with a grid or mesh where the electron beam is positioned, and a large part of the beam passes through to the region of the reflector. Since the reflector is negative with respect to the cavity, the electron beam is repelled and returns to the cavity. A given cavity resonance will establish an oscillation period and if the time required for the electron beam to pass the cavity, be

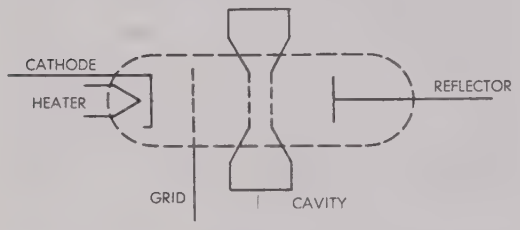


Figure 10A. Typical Reflex Klystron, Schematic View

repelled and return has the proper relationship to the oscillation period, the klystron will oscillate. Almost any multiple of the minimum time for oscillation could result in klystron output, but in the practical tube there are usually only 2 or 3 reflector voltage ranges which are within the operating limits for the tube structure. These ranges of reflector voltage correspond to oscillation modes in the tube.

For any single cavity resonance, there is one optimum reflector voltage in each mode for maximum power output. On either side of the optimum voltage, output decreases with reflector voltage change until oscillation ceases. Figure 10B shows the relationship between frequency, power output, and reflector voltage for a typical klystron. Some tubes have broader modes than others. Some are quite sensitive to loading, cavity tuning, and tube current. If the reflector voltage is sawtooth modulated, it can be adjusted to start below a mode, sweep through it, and end at some point above it. See figure 11. The klystron output is then swept from a non-oscillating condition into the mode, increasing to maximum and then decreasing to the non-oscillating state once more.

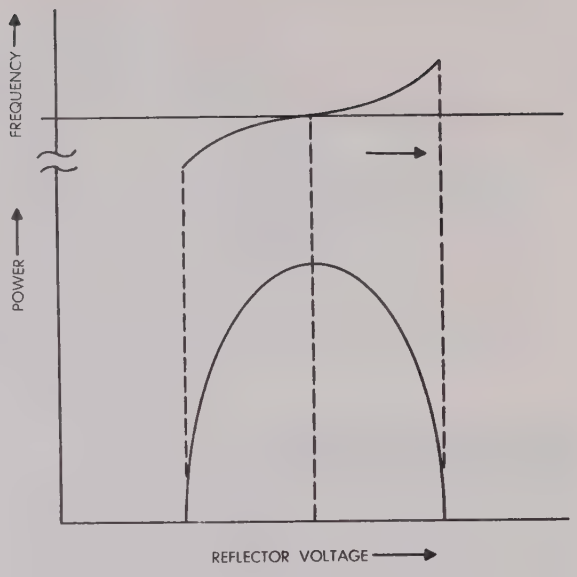


Figure 10B. Typical Mode Pattern

Klystron Tuning

For stable klystron operation, a single mode should appear as a smooth curve such as that in figure 12A. If the tube sees a highly reactive load, or if it is sensitive to grid voltage setting, the mode may show discontinuity or abrupt change in power output as shown in figure 12B. If such a discontinuity is present, the tube may be unstable when switched to square wave or CW operation. Grid voltage, beam voltage, klystron cavity tuning, setup tuning or a combination of several of these may be adjusted to obtain a smooth mode in nearly all tubes.

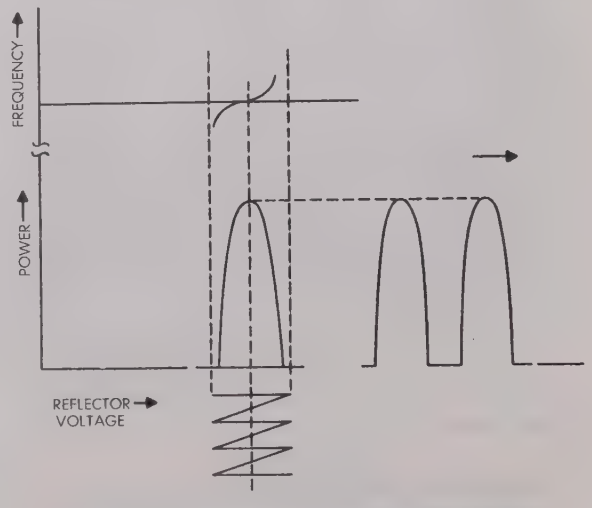


Figure 11. Sawtooth Modulation of Reflector

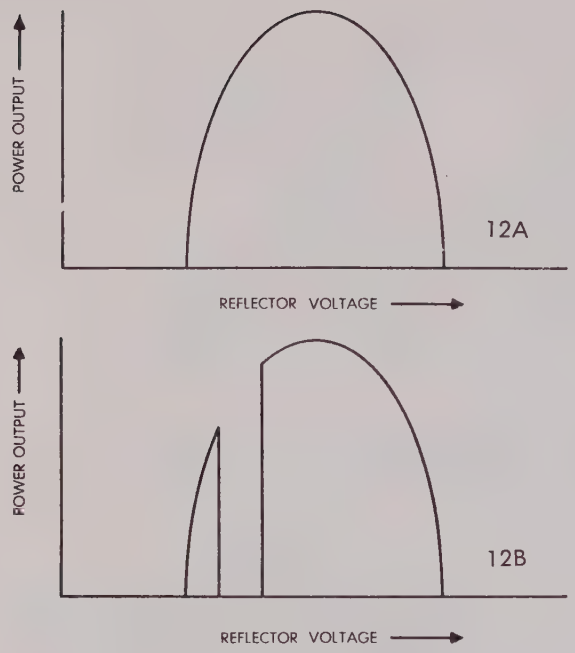


Figure 12. Klystron Mode Patterns

Klystron Modulation

Square wave reflector modulation is used for most measurements. After the klystron is adjusted for a smooth output mode, the modulator is switched to square wave operation and reflector voltage adjusted slightly for maximum power output. Square wave amplitude should be sufficient to switch the reflector voltage from the center of the mode to a value completely out of the mode as shown in figure 13. Amplitude must not be large enough to switch the klystron from one mode to another. Klystron output is therefore chopped at the modulating rate. Phase of the output modulation with respect to the modulating waveform depends on whether the square wave is switching into the mode from a higher voltage or from a lower voltage.

Klystron Frequency

Klystron frequency is also varied with reflector voltage, with the rate of variation dependent on the tube type, internal voltage relationships and several other factors. The phase of the reflected electron beam with respect to the cavity resonant frequency will cause the output frequency to be pulled one way or the other depending on whether the reflector voltage is higher or lower than the optimum value. This property of the klystron permits frequency modulation of the signal by amplitude modulating the reflector voltage. It also makes a very simple automatic frequency control system feasible. Output voltage from a simple discriminator may be used to correct the reflector voltage of a klystron and minimize frequency deviation from the desired frequency. Frequency variation with reflector voltage is shown in figure 10B.

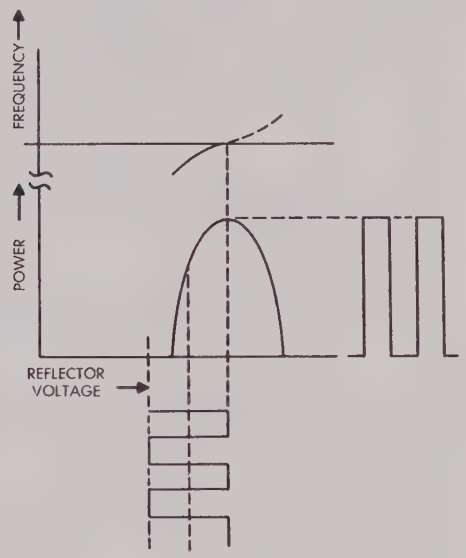


Figure 13. Klystron Operation with Square Wave Modulation

General Setup

A basic microwave setup is shown in figure 14. The 62A1 supplies power to the klystron whose output is connected to the waveguide through a level set attenuator. The frequency meter and slotted line with an SWR indicator are used for tuneup and adjustment as well as in operation. For preliminary adjustment, a termination on the waveguide output is advisable. An oscilloscope is an extremely valuable accessory in microwave bench work, although it is not absolutely essential.

Checking for Oscillation

After the setup has been made and klystron beam voltage and current set, sawtooth modulation is applied to the reflector by turning the MODULATOR switch to sawtooth. FREQUENCY may be any value, but is usually set at the low end of the range to minimize possible klystron mode distortion. AMPLITUDE is set about mid-range. The oscilloscope is connected to the slotted line probe and MOD OUT from the 62A1 used as external sweep for the scope trace. Attenuation in the level set attenuator is reduced while the oscilloscope trace is observed for some indication of klystron output. Probe position along the slotted line is not critical with a termination on the setup, but probe penetration and tuning must be optimized as

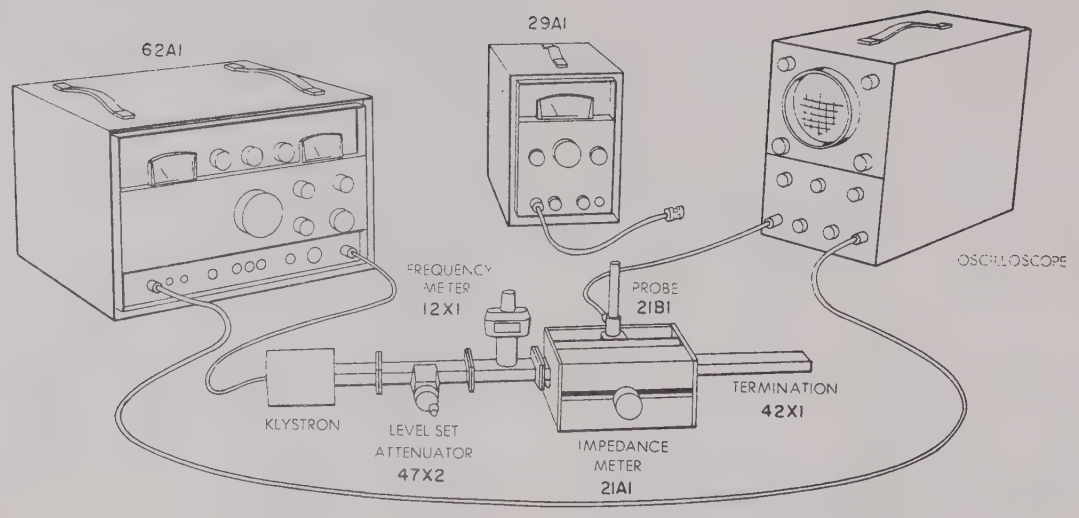


Figure 14. Typical Microwave Test Setup

soon as output is detected. If no klystron output is detected with the above adjustments, the 62A1 REFLECTOR control should be turned to bring the klystron mode within the range of modulated reflector voltage. BE SURE THAT THE MAXIMUM RATED KLYSTRON REFLECTOR VOLTAGE IS NOT EXCEEDED WHILE TURNING THE CONTROL AND WATCHING FOR AN INDICATION. Beam current in a reflex klystron is almost constant whether it is oscillating or not. The amount of change varies from one tube type to another and is not a dependable indicator for all tubes.

Tuning the Klystron

After adjustments are complete to display a single mode trace on the scope, adjust the frequency meter until a pip appears in the mode. The frequency indicated with the pip positioned in the center of the mode is very close to the CW output frequency of the klystron. If the klystron is not set to the desired frequency, it is usually not difficult to "walk" the klystron tuning, reflector voltage and frequency meter up or down to the proper operating point. If adjustments are made so the pip at the desired frequency is in the center of the mode, the frequency can be "trimmed" with the reflector control in CW operation to the exact value with maximum power output for the mode in use.

Setting Frequency and Power Output

After the frequency has been set approximately and the klystron adjusted for stable operation, modulation may be switched to square wave for measurements and reflector voltage adjusted for maximum output. The oscilloscope is replaced with the SWR indicator and modulator FREQUENCY adjusted for maximum indication.

All tuning adjustments in the setup may now be trimmed, including klystron frequency. The frequency meter will cause a dip indication on the SWR indicator when its resonant frequency matches the klystron, and the REFLECTOR control can be adjusted to bring klystron output to the desired frequency.

The setup is now ready for measurements.

USING AN EXTERNAL FILAMENT SUPPLY

The internal klystron filament supply in the 62A1 is rated at 6.3 volts ac, 4 amperes maximum. If an external filament supply is desired, internal filament connections in the 62A1 may be disabled and the external source conveniently connected to appear at the OUTPUT connector.

Access to the filament circuit is provided by the KLYSTRON FIL. JUMPER terminals at the rear of the chassis. Normal connections from the internal filament supply to the output connectors are shown in figure 15. The internal filament winding is connected to terminals 1 and 2 with terminals 1 and 3 connected to the OUTPUT connectors. To insert an external filament source, remove the protective plate over the access hole and make the connections shown in figure 16. The connecting link should be turned well away from terminal 3 and tightened securely so it is clear of any surrounding metal parts.

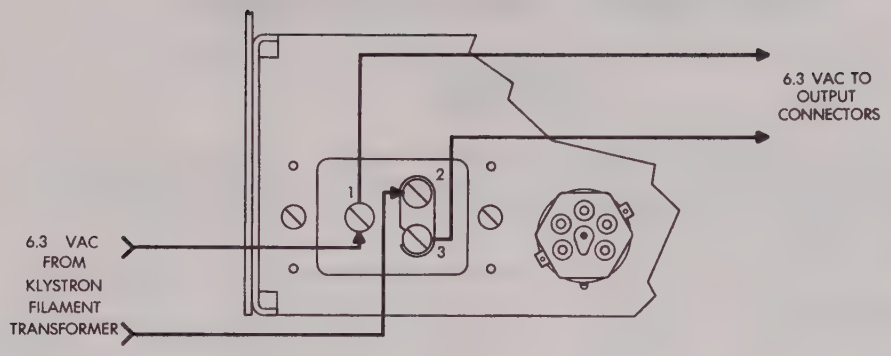


Figure 15. Klystron Filament Jumper Board Connections, Internal Filament Supply

CAUTION

Since the filament circuit is connected to the beam in the klystron or in the output cable, the connection above is at high voltage. All external wiring and power supplies connected in this circuit must be insulated for the full beam voltage to be used and protective measures taken for personnel safety. All power on the 62A1 must be turned off before making any connections to the KLYSTRON FIL. JUMPER board. Output cables should be removed to break the connection between the filament circuit and the beam.

The narda *Microline* Model 62A2 DC Klystron Filament Supply is designed to operate as an accessory with the 62A1. It provides well-regulated filament power from 2.5 to 10 volts at low ripple with 2 amperes capacity. When connections are made to the KLYSTRON FIL. JUMPER board from the 62A2 and its power cord plugged into the ACC socket on the rear of the chassis, the filament supply will be turned on and off with the 62A1. No time delays or other special considerations are required since the 62A2 is transistorized and requires no warmup.

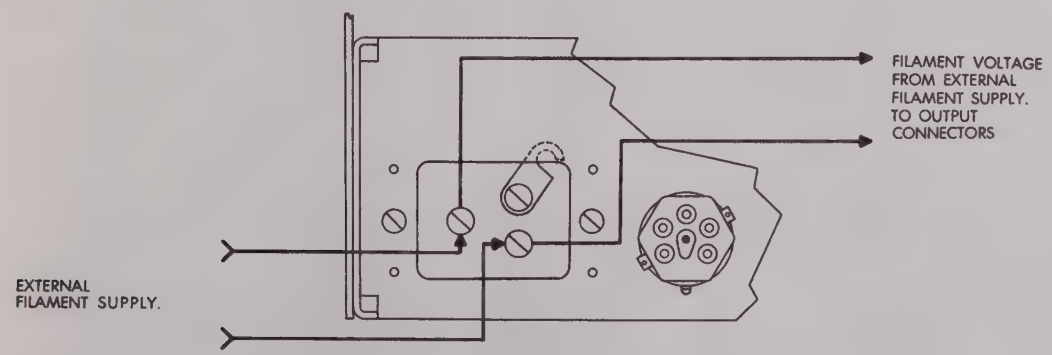


Figure 16. Klystron Filament Jumper Board Connections, External Filament Supply

MAINTENANCE AND ADJUSTMENT

CAUTION

High voltages in excess of 5000 volts dc are present in this equipment. Use extreme caution in operating or servicing this unit when removed from its cabinet. Remember that the entire reflector deck rides at the beam potential.

GENERAL INFORMATION

Major test points and controls are readily accessible without removing the 62A1 from its case. Internal modulator and reflector deck adjustments are made available by pulling the equipment about 4 inches out of the case. The unit must be removed from the case entirely for access to filament regulator settings. While the internal controls seldom require adjustment, periodic preventive maintenance should include measurement of klystron operating voltage ranges and modulator characteristics.

A power source of 105 to 125 volts, 60 cps, single phase, 875 watts maximum is assumed for these measurements. The following test equipment is required.

1. Calibrated oscilloscope.
2. D-c voltmeter with 5000 volt capability, 20,000 ohms per volt.
3. A-c VTVM capable of 3 millivolt full scale measurements.
4. High voltage (5000 volt minimum) coupling capacitor for scope and VTVM inputs.

REMOVING THE EQUIPMENT FROM THE CASE

a. Remove 4 screws from each trim channel on either side of the panel.
b. Release the captive screw at the rear of the chassis and slide the unit forward out of the case.

All angles around the panel are on self-locking floating nuts to permit alignment when replacing the unit. The trim tees at the top and bottom are aligned at the factory and should never require readjustment.

INITIAL ADJUSTMENTS

a. Turn on POWER switch, and allow 20 minutes for warmup.
b. With positive lead of d-c voltmeter at COM terminal and negative lead at the REF test point, —300 to —320 volts should be indicated. (See figure 17.) The exact value of this voltage is not important, but it should be within the range above. Ripple measured between these two points must not exceed 3 millivolts average, measured with the a-c VTVM.
c. Move negative lead of d-c voltmeter to pin B of OUTPUT connector. Set BEAM control on front panel to —200 volts and meter range to 5000 volts. Turn on BEAM switch and advance BEAM control to —4000 volts. Set BEAM ADJ control for an indication of —4000 volts dc on meter.
d. Return BEAM control on front panel to —200 volts. Adjust BEAM RANGE control for —200 volts dc reading on meter.
e. Ripple on beam voltage must not exceed 3 millivolts average at any voltage in its range with any load from 0 to maximum rated current. DO NOT EXCEED 150 MA OR 360 WATTS AT ANY TIME.

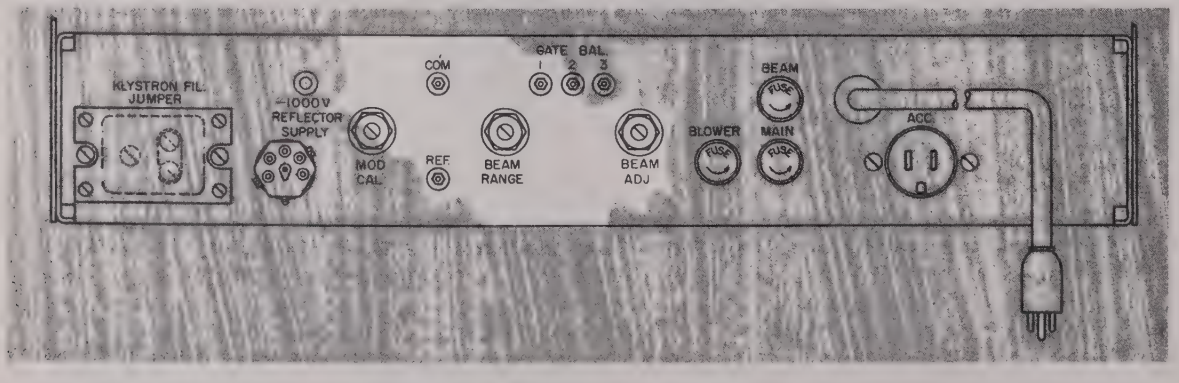


Figure 17. Reference Measurements

NOTE

Be sure that a high voltage coupling capacitor is used on the a-c VTVM input at high beam voltages. Most VTVM's are not equipped for measurements on d-c voltages above 600 volts.

INTERNAL ADJUSTMENTS AND MEASUREMENTS

CAUTION

Be sure the BEAM switch is off for the following. REMEMBER — FULL REFLECTOR VOLTAGE IS PRESENT WHEN POWER IS ON.

Filament Regulator Adjustment

Transistorized filament regulator circuits in the reflector deck and in the main beam chassis should require little if any attention. If it is necessary to adjust them, the following procedure should be used.

a. To set the reflector filament regulator, connect d-c voltmeter as shown in figure 18, and adjust R130 for 5.8 volts. This average value of clipped waveform corresponds to 6.3 volts rms.

b. To set beam supply filament regulator, connect d-c voltmeter leads as shown in figure 19 and adjust R52 for 6.3 volts.

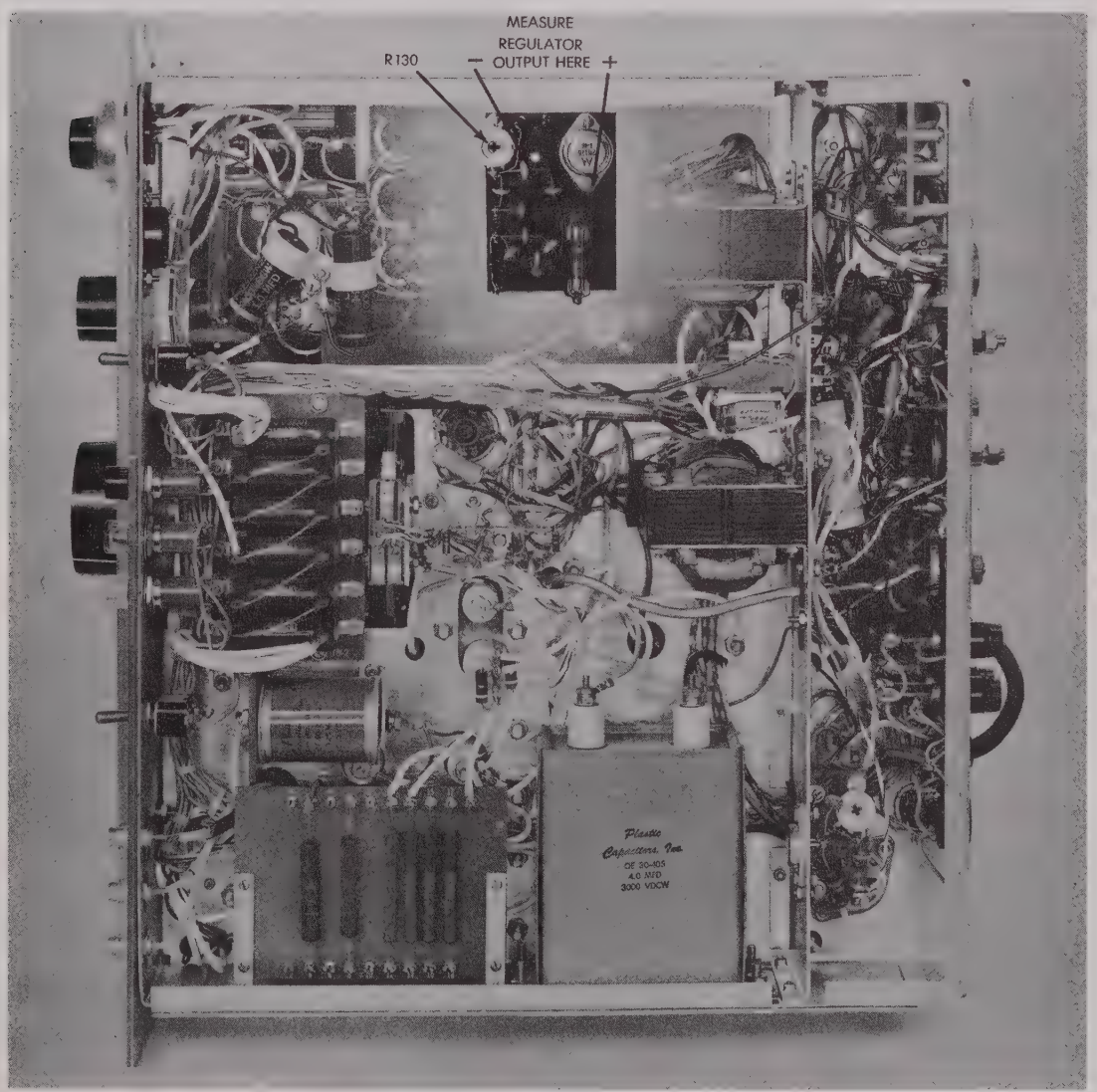


Figure 18. Reflector Filament Adjustment

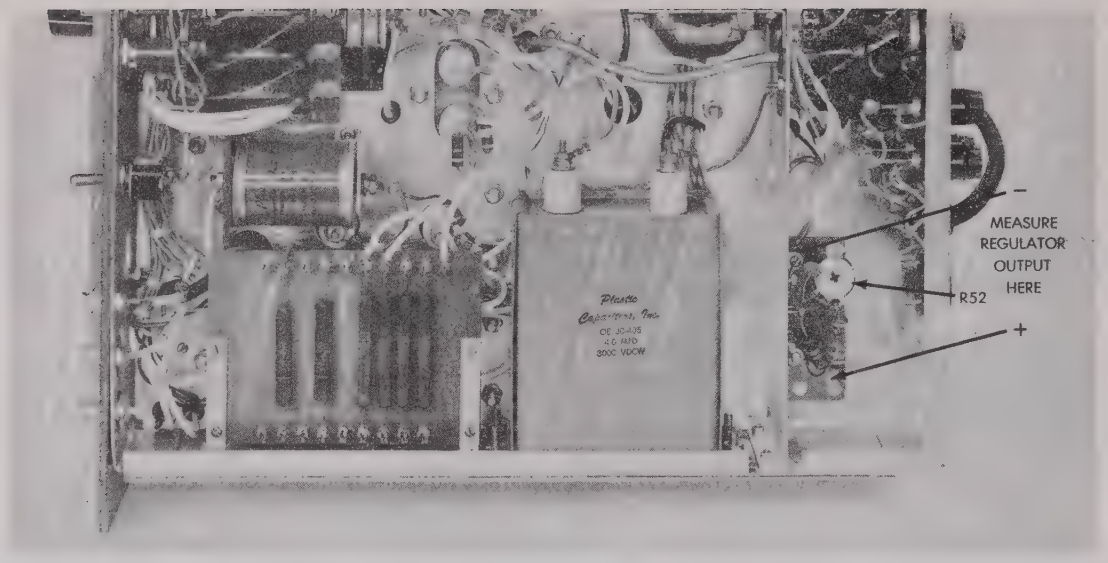


Figure 19. Beam Filament Regulator Adjustment

Reflector Voltage Range

a. To measure reflector voltage, connect positive d-c voltmeter lead to pin B and negative lead to pin A at OUTPUT connector.

NOTE

Because of the 270K series resistor used for modulator coupling load, a 20,000 ohms per volt meter will read about 1.5% low, but it is seldom necessary that the actual reflector voltage be known with high accuracy.

b. Advance front panel REFLECTOR control fully clockwise.

c. Adjust R111 on reflector deck (see figure 20) for 1000 volts dc on the meter. A friction type shaft lock is provided on R111 to insure stability of this adjustment. It need not be loosened to make the adjustment.

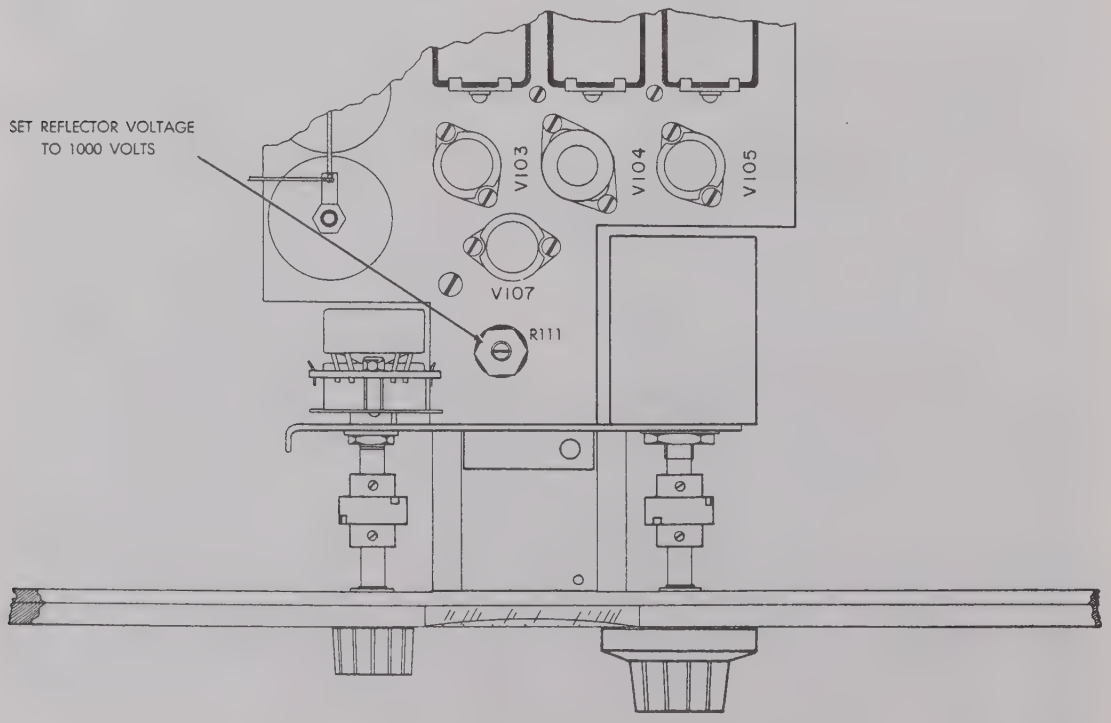


Figure 20. Reflector Voltage Adjustment

d. Measure ripple at same points with VTVM; it should be less than 3 millivolts average. Protect VTVM input with high voltage coupling capacitor if necessary. Because of very low ripple level, care must be taken to prevent hum and noise pickup through meter leads or in ground loops through measuring equipment.

Control Grid Bias Voltages

No adjustment is required for the control grid bias voltages. Grid voltage range may be checked with a d-c voltmeter between pins C and A at the OUTPUT connector. Grid voltage polarity is chosen by the GRID SELECT switch and magnitude by the GRID potentiometer. Grid voltage is adjustable from 0 to approximately +150 volts and 0 to approximately —300 volts. Ripple should be less than 5 millivolts average.

Modulator Adjustments

The following adjustments are made without removing the modulator from the 62A1. Reflector must be advanced to about 400 volts to prevent waveform clipping.

a. Connect an oscilloscope probe to MOD OUT jack on front panel.
b. Rotate the MODULATION switch to ⩙ position.
c. Turn AMPLITUDE control fully clockwise and FREQUENCY control to about mid-position.
d. Adjust R205 (see figure 21) for maximum linear sawtooth amplitude. Exact frequency is not important for this step. Amplitude should be 200 volts peak to peak or greater.
e. Set FREQUENCY control to maximum CCW and adjust R215 for a sawtooth frequency of 40 cps.
f. Advance FREQUENCY control to maximum CW position. Output frequency should be 400 cps or greater.
g. Switch MODULATION to ⊓⊔ position and adjust R216 for 200 volts peak to peak.
h. With FREQUENCY control in maximum CW position, measure square wave frequency. It should be 2000 cps or higher.
i. Turn FREQUENCY control to maximum CCW position. Measure output frequency. It should be 200 cps or less.
j. Measure rise and fall time of square wave. Fall time should be less than 1 microsecond (10% and 90% amplitudes), and rise time should be less

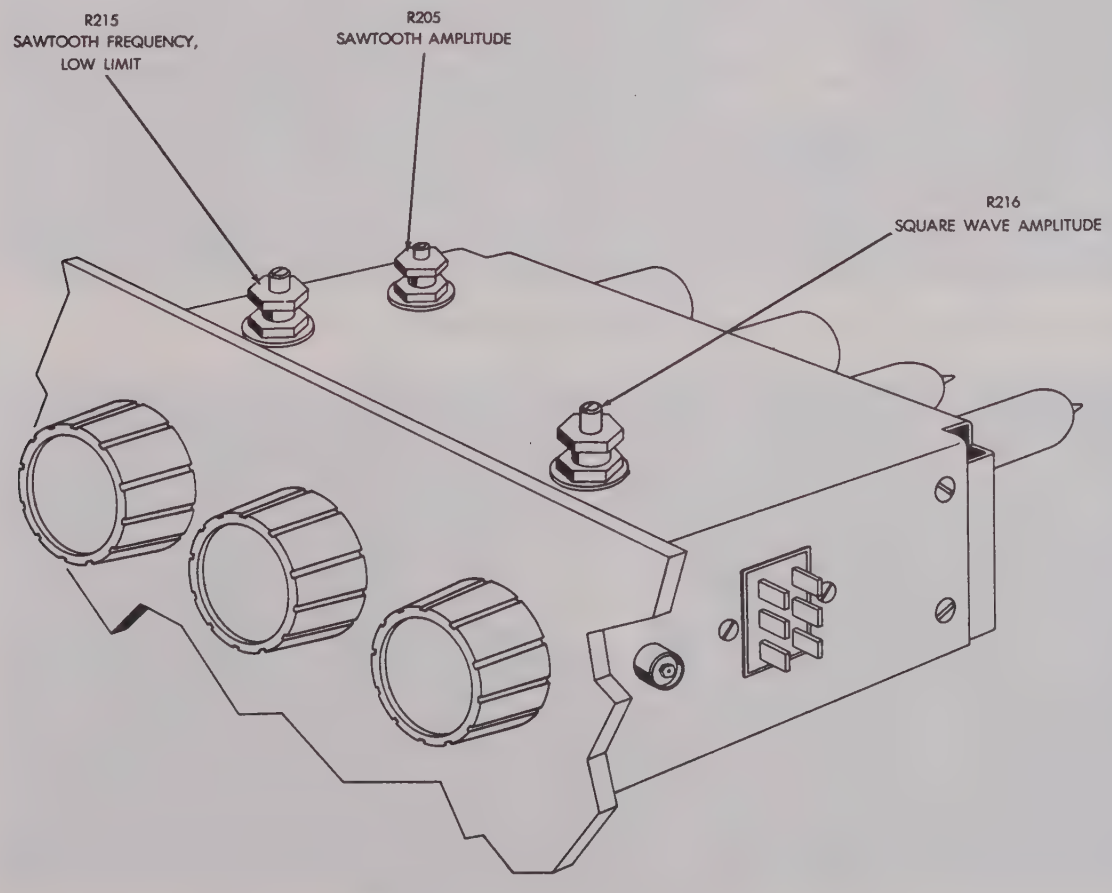


Figure 21. Modulator Adjustment

than 2 microseconds. If necessary, R216 can be adjusted to meet these rise and fall times.

k. Place MODULATOR switch in ~ position.

l. Set line voltage to 125 volts and adjust MOD CAL control on rear of the chassis (See figure 22) for maximum undistorted sine wave output. It should be greater than 200 volts peak to peak.

Current Balance Measurement

A periodic check should be made of the current division among the three gate tubes in the beam regulator. Test points are provided on the rear of the chassis for this measurement. See figure 23. The following procedure should be used.

a. Connect a load resistor capable of handling 75 ma or more to beam output between pins B and F. Exact value is not important.

b. Set OVERLOAD switch to 150.

c. Turn on BEAM switch and adjust BEAM control for 75 ma or more. Exact current value is not important, but must exceed 75 ma.

d. Connect negative lead of d-c voltmeter to COM jack on rear of chassis. Measure voltage drop across the balance resistors at GATE BAL points 1, 2 and 3 in turn, with positive meter lead. Actual voltage is not important, but measurements should be within ±10% of each other.

If excessive unbalance is indicated, one or more of the 6CD6GA tubes must be replaced.

Current balance at beam loads of less than 75

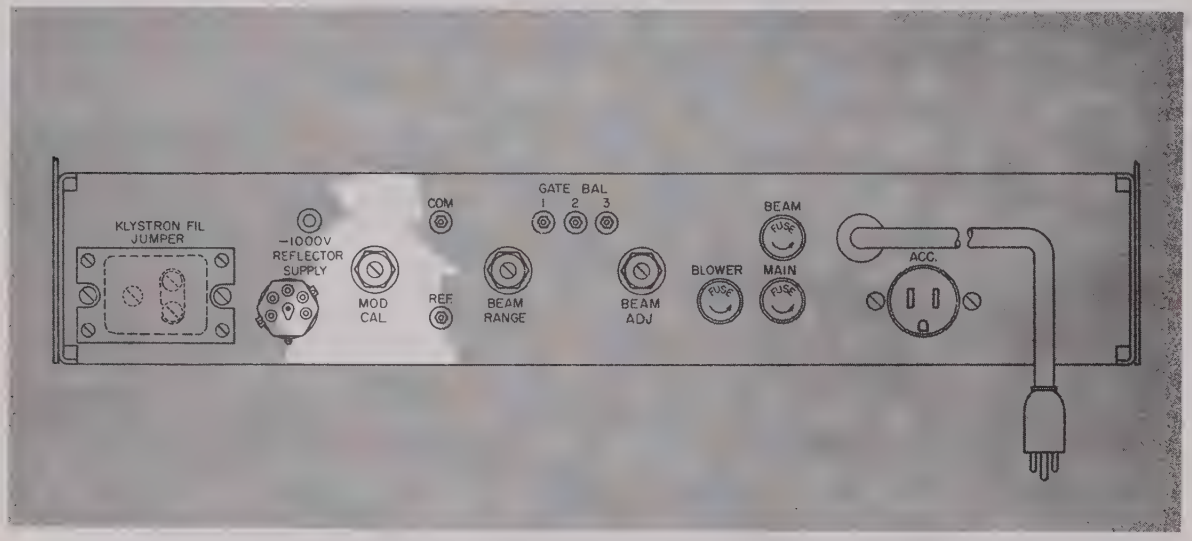


Figure 22. MOD CAL Adjustment

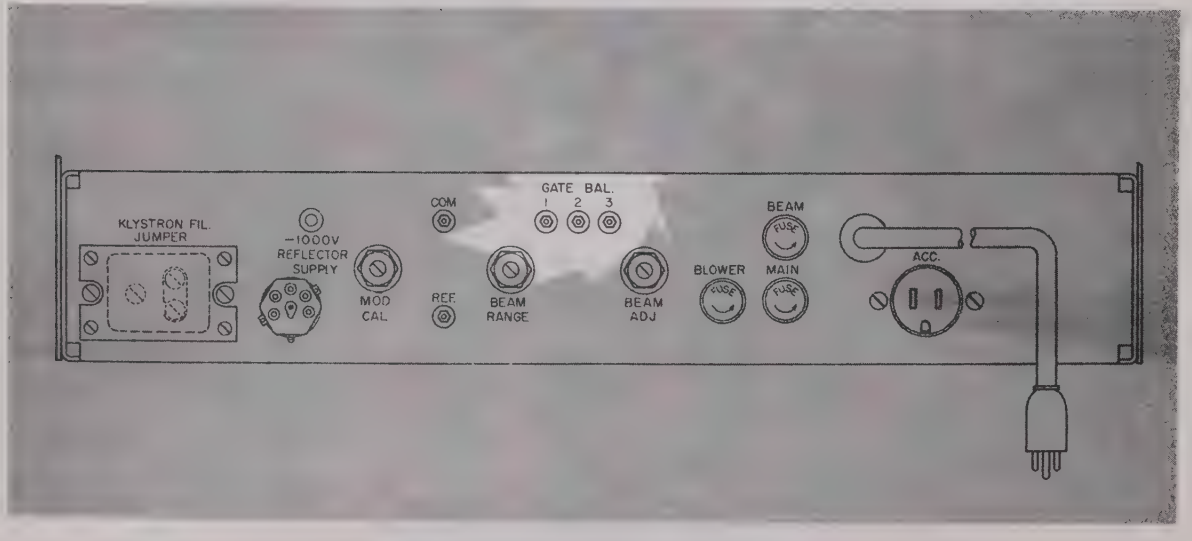


Figure 23. Gate Balance Measurement

ma is relatively unimportant, since any one of the 6CD6GA tubes can handle up to 50 ma. The only effect of current unbalance at higher load currents is a shortening of 6CD6GA life.

6CD6 Replacement

Occasionally a 6CD6 is encountered which is not suitable for gate service. Tubes falling into this category may be recognized by loss of regulation in the 62A1 at very light loading, particularly toward the low-voltage end of the beam voltage range. When beam current is reduced to 2 or 3 ma, the power supply will regulate initially then drift rapidly out of its regulation range—possibly 3 or 4 volts. If 62A1 operation under very light loading is required, 6CD6 tubes should be checked for this characteristic whenever a replacement is necessary. All 62A1's are tested for no load regulation at the factory, and any 6CD6 tubes incapable of meeting light load requirements are rejected.

Capacitor Balance (C1-C2)

If capacitors C1 and C2 become widely separated in capacity, ripple in the doubler output voltage will increase and ripple on the beam voltage may become excessive. If it is necessary to replace either C1 or C2, beam output ripple should be checked with the new capacitor under full load over its range.

CAUTION
Do not exceed 150 ma or 360 watts!

If more than 3 millivolts is observed after capacitor replacement, check the waveform from the voltage doubler. It should be a 120 cps waveform similar to a sawtooth. If alternate cycles are considerably different in amplitude, excessive unbalance in C1 and C2 is indicated. Simple capacity measurement is not necessarily a true indicator of performance as a filter capacitor in the doubler, and in-circuit performance must be checked to be sure of a suitable replacement.

Replacing Wirewound Resistors (R45, 47, 48, 49, 50)

If resistors R45, R47, R48, R49 or R50 are replaced, low temperature coefficient wirewound resistors should be used. Any 1% wirewound resistor of the proper value with a temperature coefficient of 50 ppm °C or better is suitable.

Replacing 2E4 Rectifiers

If replacement is necessary for any of the 2E4 silicon rectifiers, any silicon rectifier with 400 volt PIV and 200 ma or better forward current rating is suitable. However, in the case of CR5, CR6, CR109 and CR110, check to see that the forward drop at 10 ma dc is between 0.6 volt and 0.72 volt. These are reference elements in the filament regulator and replacement rectifiers with a forward drop outside this range may result in improper operation.

Modulator Subassembly

If the modulator subassembly is to be tested or serviced remotely from the power supply, regulated 300 volts dc at 35 milliamperes and 6.3 volts ac unregulated at 1.75 amperes are required. The 300-volt dc supply **must** have a source impedance of one ohm or less from dc to one megacycle. A 250-ohm two watt potentiometer, connected across the 6.3-volt ac source, is used to set the level of the sine wave modulation signal. See figure 24 and proceed as follows.

1. Remove the FREQUENCY, MODULATOR, and AMPLITUDE knobs.
2. Unplug the five cables connecting the modulator to the main chassis.
3. Remove the nuts holding the modulator controls to the chassis.
4. Slide the subassembly to the rear.
5. To re-install the modulator subassembly, reverse the above procedure.

NOTE

Before tightening the nuts holding the panel controls, be sure the locating lugs on the two potentiometers and switch are seated properly in the holes in the modulator chassis.

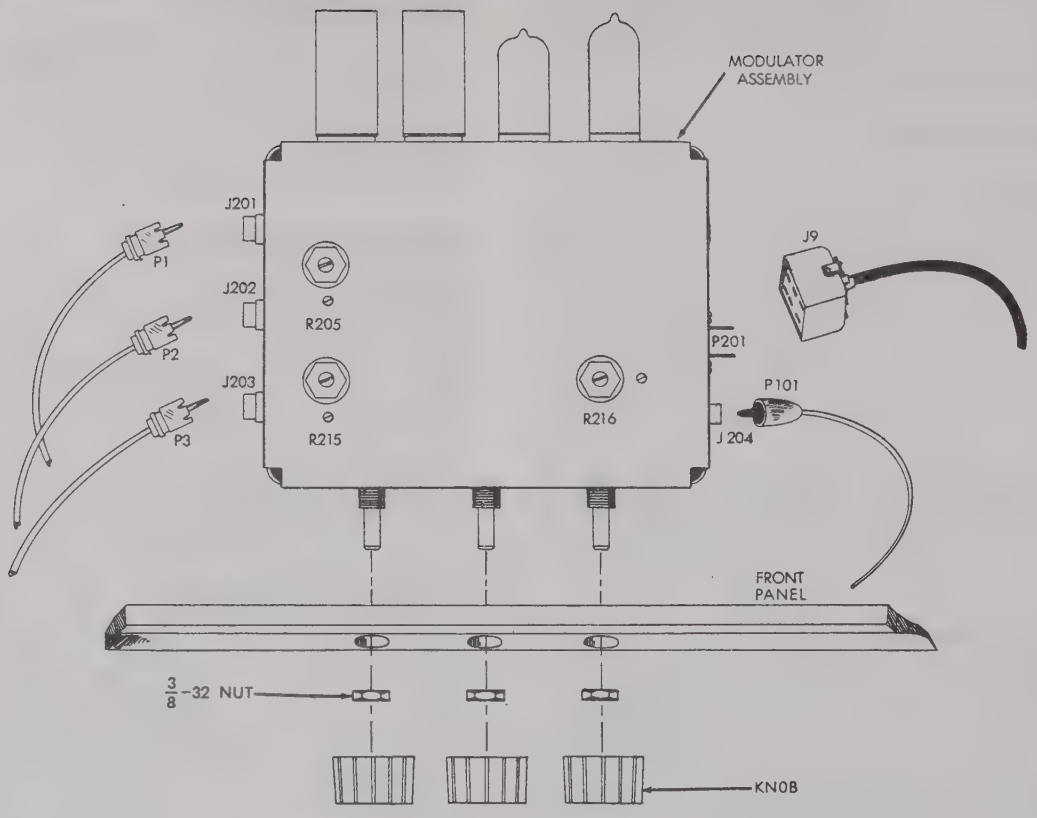


Figure 24. Removing Modulator Subassembly

TROUBLESHOOTING CHART

Trouble	Probable Cause	Remedy
POWER lamp does not light. POWER switch at ON.	Blown fuse; no primary power; POWER switch defective; POWER lamp burned out.	Check connection at a-c power source; check fuses; check POWER lamp; check POWER switch and associated circuitry.
BEAM READY lamp does not light.	Defective time delay relay K4. Blower fuse.	Replace K4, blower fuse.
BEAM READY lamp lighted, BEAM lamp does not come on when BEAM switch is thrown to ON.	BEAM switch defective; overload relay stuck open; fuse in beam supply blown; relay K1 defective.	Check BEAM switch and associated wiring; check tubes; check overload relay; check fuse in beam supply.
BEAM lamp lighted, beam voltage present, no indication of beam current with klystron attached to OUTPUT connector.	Incorrect wiring of cable to klystron under test; defective klystron; grid voltage excessively negative; overload current setting too high.	Check cable to klystron; substitute klystron known to be operable; check settings of GRID SELECT switch; check OVERLOAD switch setting.
BEAM VOLTS meter indication erratic.	Dirty contacts or faulty operation of relay K2.	Check K2.

TROUBLESHOOTING CHART (Continued)

Trouble	Probable Cause	Remedy
Beam voltage does not cover proper range.	Equipment not completely warmed up; incorrect setting of BEAM RANGE and/or BEAM ADJ. controls on rear of chassis; V9, V10, V11, V12, V13 defective.	Allow at least ten minutes for equipment to warm up; check beam supply voltage; check tubes.
Beam voltage outside range, no regulation, excessive hum.	V3, V4, V5 shorted; heater regulator Q1 defective; defective component in beam regulator; faulty reference supply; distorted line voltage.	Replace V3, V4, V5; replace Q1; check beam regulator circuitry; check reference supply.
Operation normal, klystron under test does not oscillate.	Defective klystron; incorrect reflector voltage; no reflector voltage; V107 shorted.	Substitute klystron known to be operable; rotate REFLECTOR control and watch for proper klystron operation; check for presence of reflector voltage; replace V107.
Excessive ripple on beam supply voltage.	Tube defective; current drawn at high beam voltage exceeds 360 watts power drain; current drawn at low beam voltage exceeds 150 ma; C1, C2 defective; distorted line voltage.	Check tubes; check current and/or power delivered to load; check C1, C2. Use line harmonic filter.
Voltage differential as measured at GATE BAL 1, 2 and 3 test points greater than 10 percent with klystron under test drawing beam current.	V3, V4, V5 weak or defective.	Check tubes by substitution.
Overload relay will not remain closed; no klystron or cable attached to OUTPUT connector.	Short circuit in beam voltage supply.	Check tubes; components and wiring in beam voltage supply; check wiring associated with both OUTPUT connectors.
Overload relay will not remain closed with klystron attached to OUTPUT connector; correct operation with klystron cable removed.	Incorrect wiring of cable to klystron under test; defective klystron; incorrect setting of GRID control and/or GRID SELECT switch; overload current setting too low.	Check cable to klystron; substitute klystron known to be operable; check settings of GRID control and GRID SELECT switch; check setting of OVERLOAD switch.
No reflector voltage.	Incorrect setting of REFLECTOR control; defective tubes and/or components in reflector supply; silicon rectifiers faulty.	Rotate REFLECTOR control and check for presence of reflector voltage; check tubes and circuitry of reflector supply; check silicon rectifiers.
Reflector voltage out of range or not regulated.	Defective tubes in reflector supply; heater regulator transistor Q101 defective; capacitor C106 shorted.	Check tubes; check Q101; check C106.

TROUBLESHOOTING CHART (Continued)

Trouble	Probable Cause	Remedy
Excessive ripple on positive grid voltage.	V106 defective.	Check V106.
No negative grid voltage.	GRID SELECT switch at OFF; GRID control at zero; R113, R114, R115 defective.	Check settings of GRID SELECT switch and GRID control; check R114, R113, R115.
Excessive ripple on negative grid voltage.	V101 through V105 defective; C106 open.	Check tubes; check C106.
Poor beam regulation or no regulation.	Modulator plug P201 disconnected from Jack J9.	Connect P201 to J9.
	V204 defective.	Check V204.

MANUFACTURER'S CODE

A Aerovox Corp.
New Bedford, Mass.

B Amperex Electronics Corp.
Hicksville, N. Y.

C Allen-Bradley Co.
Milwaukee 4, Wis.

D Aemco, Inc.
Mankato, Minn.

E Arrow, Hart and Hegeman
Hartford, Conn.

F Advance Electric & Relay Co.
Burbank, Calif.

G Alcon Metal Products, Inc.
Chicago, Ill.

H Amphenol Electronics Corp.
Chicago 50, Ill.

I Amperite Co.
New York, N. Y.

J Astron Corp.
East Newark, N. J.

K All Star Products, Inc.
Defiance, Ohio

L Any brand tube meeting
EIA standards

M Beede Electrical Instrument Co.
Penacook, N. H.

N Belden Mfg. Co.
Chicago 44, Ill.

O Bud Radio Inc.
Cleveland, Ohio

P Barber-Colman Co.
Rockford, Ill.

Q Bussman Mfg. Co.
St. Louis, Mo.

R Birnbach Radio Co.
New York 13, N. Y.

S Narda Microwave Corporation
Plainview, N. Y.

T Clarostat Mfg. Co.
Dover, N. H.

U Chicago Telephone Supply
Elkhart, Ind.

V Centralab Div. Globe Union, Inc.
Milwaukee 1, Wis.

W Cinch-Jones Mfg. Co.
Chicago 24, Ill.

X Corning Glass Works
Bradford, Pa.

Y California Resistor Corp.
Santa Monica, Calif.

Z Cornell-Dubilier Electric Co.
So. Plainfield, N. J.

AA Dage Electric Co., Inc.
Beech Grove, Ind.

AB Dial Light Co. of America
Brooklyn 37, N. Y.

AC Dale Products, Inc.
Columbus, Neb.

AD Hugh H. Eby Co.
Philadelphia, Pa.

AE Erie Resistor Corp.
Erie 6, Pa.

AF Essex Electronics, Inc.
Berkeley Heights, N. J.

AG Electro Motive Mfg. Co.
Willimantic, Conn.

AH Electra Mfg. Co.
Kansas City, Mo.

AI General Electric Co.
Owensboro, Ky.

AJ Fischer Electric Co.
De Leon Springs, Fla.

AK Gremar Mfg. Co.
Wakefield, Mass.

AL Hammarlund Mfg. Co., Inc.
New York 1, N. Y.

AM Heyman Mfg. Co.
Kenilworth, N. J.

AN Hi-Q Div. of Aerovox Corp.
Myrtle Beach, S. C.

AO IEI
Nashville, Tenn.

AP Industrial Devices, Inc.
Edgewater, N. J.

AQ International Rectifier Corp.
El Segundo, Calif.

AR International Resistance Co. (IRC)
St. Petersburg, Fla.

AS E. F. Johnson Co.
Waseca, Minn.

AT James Millen Mfg. Co., Inc.
Malden, Mass.

AU Kulka Electric Mfg. Co., Inc.
Mount Vernon, N. Y.

AV Kelvin Electric Co.
Van Nuys, Calif.

AW Line Electric Co.
Newark, N. J.

AX Littelfuse, Inc.
Des Plaines, Ill.

AY M.E.C.
Nashville, Tenn.

AZ J. W. Miller Co.
Los Angeles, Calif.

BA Motorola, Inc.
Phoenix, Ariz.

BC North American Electronics, Inc.
Lynn, Mass.

MANUFACTURER'S CODE (Continued)

BD Oak Mfg. Co.
Chicago 10, Ill.

BE Ortho Industries
Paterson, N. J.

BF Potter and Brumfield, Inc.
Princeton, Ind.

BG Plastic Capacitors, Inc.
Chicago, Ill.

BH Peterson Radio Co.
Council Bluffs, Ia.

BI Philco Corp.
Lansdale, Pa.

BJ Raytheon Mfg. Co.
Newton, Mass.

BK Radio Materials Co. (R.M.C.)
Chicago, Ill.

BL R.C.A. Tube Division
Harrison, N. J.

BM Radio Receptor Co., Inc.
Brooklyn, N. Y.

BN Superior Electric Co.
Bristol, Conn.

BO Sylvania Electric
Emporium, Pa.

BP Switchcraft, Inc.
Chicago 22, Ill.

BQ Herman H. Smith, Inc.
Brooklyn, N. Y.

BR Synchro Corp.
Hicksville, Ohio

BS Sloan Co.
Burbank, Calif.

BT Triad Transformer Co.
Huntington, Ind.

BU Tepro of Florida, Inc.
Dunedin, Fla.

BV Texas Instruments, Inc. (T.I.)
Dallas, Texas

BW Transformer Technician, Inc.
Chicago, Ill.

BX Tung-Sol Electric, Inc.
Newark 4, N. J.

BY Unimax Switch Division
Wallingford, Conn.

BZ Veeder Root, Inc.
Hartford, Conn.

CA Winchester Electronics, Inc.
Santa Monica, Calif.

TABLE OF REPLACEABLE PARTS

Reference Designation	Description	Mfr. Code	Narda Part No.	Quantity Per Unit
B1	Bulb, Neon, Type NE-2A	BX	A-018S2-3	1
C1	Capacitor: 4uf, 3 kv	BG	B-02201-203	1
C2	Capacitor: 4 uf, 3 kv	BG	B-02201-103	1
C3	Capacitor: 2 uf, 3 kv	BG	B-02201-102	2
C4	Same as C3			
C5	Capacitor: 2 uf, 2 kv	BG	B-02201-101	2
C6	Same as C5			
C7	Capacitor: 0.25 uf, 4 kv	BG	B-02200-1	1
C8	Capacitor: 40-20 uf, 250 v	A	C-02235-202	1
C9	Capacitor: 0.25 uf, 400 v	A	A-01201-404	2
C10	Capacitor: 40-40 uf, 450 v	A	C-02235-205	1
C11	Capacitor: 0.1 uf, 200 v	A	A-01202-205	1
C12	Same as C9			
C13	Capacitor: 0.05 uf, 600 v	BK	A-01210-050	1
C14	Capacitor: 0.1 uf, 400 v	A	A-01202-405	1
C15	Capacitor: 150 pf, 500 v	V	A-01205-151	2
C16	Capacitor: 20 uf, 450 v	A	A-01230-12	1
C17	Capacitor: 0.01 uf, 500 v	BK	A-01210-010	3
C18	Same as C15			
C19	Capacitor: 680 uf, 20 v	AO	A-01231-5	1
C20	Capacitor: 560 uf, 6 v	AO	A-01231-2	1
C101	Capacitor: 2 uf, 1 kv	A	A-01217-101	3
C102	Same as C101			
C103	Capacitor: 40-20 uf, 250 v	A	A-01236-2	1
C104	Same as C101			
C105	Same as C17			
C106	Capacitor: 0.1 uf, 1 kv	A	A-01200-910	
C107	Not used			
C108	Capacitor: 0.25 uf, 5 kv	BG	B-02200-2	2
C109	Same as C108			
C110	Same as C17			
C111	Capacitor: 1 uf, 400 v		A-01201-406	2
C201	Capacitor: 0.02 uf, 400 v	A	A-01202-401	1
C202	Capacitor: 100 uf, 25 v	A	A-01230-3	1
C203	Capacitor: 1500 pf, ±5%, 500 v	A	015-5	1
C204	Capacitor: 22 pf, 500 v	V	A-01205-220	2
C205	Same as C204			
C206	Capacitor: 39 pf, 500 v	V	A-01205-390	1
C207	Capacitor: 0.15 uf, 400 v	A	A-01202-406	6
C208	Same as C111			
C209	Capacitor: 0.1 uf, 400 v	A	A-01202-405	1
C210	Capacitor: 220 pf, ±5%, 300 v	A	610793-31	1
C211	Capacitor: 0.01 uf, 500 v	A	A-01211-010	1
CR1	Rectifier, 2E4	AQ	A-01952	16
CR2	Same as CR1			
CR3	Same as CR1			
CR4	Same as CR1			
CR5	Same as CR1			
CR6	Same as CR1			

TABLE OF REPLACEABLE PARTS (Continued)

Reference Designation	Description	Mfr. Code	Narda Part No.	Quantity Per Unit
CR7	Rectifier, IN1692	BA	A-01953-105	4
CR8	Same as CR7			
CR9	Same as CR7			
CR10	Same as CR7			
CR101	Same as CR1			
CR102	Same as CR1			
CR103	Same as CR1			
CR104	Same as CR1			
CR105	Same as CR1			
CR106	Same as CR1			
CR107	Same as CR1			
CR108	Same as CR1			
CR109	Same as CR1			
CR110	Same as CR1			
F1	Fuse, 8 a, 125 v	Q	A-01790-8	1
F2	Fuse, 3 a, 125 v	Q	A-01790-2	1
F3	Fuse, 1 a, 125 v	Q	A-01790-1	1
F101	Fuse, 1/8 a, Slo Blo	Q	A-01790-125	1
I1	Indicator, Neon	AP	B-02850-3	1
I2	Indicator, Neon	AP	B-02850-2	1
I3	Indicator, Neon	AP	B-02850-1	1
I4	Lamp, Incandescent	BS	A-01855-11	2
I5	Same as I4			
J1	Jack, 6 pin, female	CA	A-01740-1	2
J2	Jack, BNC	AK	A-01751	3
J3	Same as J2			
J4	Same as J2			
J5	Jack, female, 3 pin, ac	H	A-01735-4	2
J6	Same as J5			
J7	Jack, White	AS	A-01720-1	1
J8	Jack, Red	AS	A-01720-2	1
J9	Jack, Black	AS	A-01720-3	1
J10	Jack, Yellow	AS	A-01720-6	3
J11	Same as J10			
J12	Same as J10			
J13	Same as J1			
J201	Jack, Phono	BP	A-01729-1	3
J202	Same as J201			
J203	Same as J201			
J204	Jack, Tip	AS	A-01720-4	
K1	Relay, 3PDT, N.O. 117 v ac Coil	AW	B-02600-1	1
K2	Relay, SPST, N.O. 6.3 v ac Coil	AW	B-02601	1
K3	Relay, SPST, N.C. .25 ma Coil	AW	B-02602	1
K4	Relay, Thermal, SPST, N.O. 60 sec. delay, 117 v ac Element	I	A-01601-1	1
L-1	Inductor, 10 H, 150 ma	AI	C-02460	1
M-1	Meter, 1 ma, 50 mv	M	B-02506	1
M-2	Meter, 25 ma, 50 mv	M	B-02505	1
Mot. 1	Fan	P	A-01900-2	1
P1	Plug, Phono	BP	B-02710-1	1
P2	Plug, Phono	BP	B-02710-2	1
P3	Plug, Phono	BP	B-02710-3	1

TABLE OF REPLACEABLE PARTS (Continued)

Reference Designation	Description	Mfr. Code	Narda Part No.	Quantity Per Unit
P4	Not used			
P5	Not used			
P6	Not used			
P7	Plug	N	A-01700-3	1
P8	Not used			
P9	Plug, male, 6 pin	W	A-01728-106	1
P101	Plug, pin tip	AS	A-01721-04	
P201	Receptacle, female, 6 pin	W	A-01728-206	1
Q1	Transistor, 2N176	BA	A-01961	
Q101	Same as Q1			
R1	Resistor, Meter Shunt, 50 Ω nom., 2 ma ±2%	M	B-02506-1	1
R2	Resistor, Fixed, Composition: 330 k, ½ w, ±5%	C	0524-109	3
R3	Resistor, Fixed, Composition: 10 k, 1 w, ±5%	C	0525-73	3
R4	Same as R3			
R5	Same as R3			
R6	Resistor, Fixed, Composition: 47 Ω , ½ w, ±5%	C	0524-17	3
R7	Same as R6			
R8	Same as R6			
R9	Resistor, Fixed, Composition: 470 Ω , ½ w, ±5%	C	0524-41	4
R10	Same as R9			
R11	Same as R9			
R12	Resistor, W.W., 3 k, 5 w	T	A-01110-302	
R13	Resistor, W.W., 2500 Ω , 5 w, ±5%	T	A-01110-252	2
R14	Resistor, Fixed, Composition: 200 k, ½ w, ±5%	C	0524-104	
R15	Resistor, Fixed, Composition: 100 k, ½w, ±5%	C	0524-97	2
R16	Resistor, Fixed, Composition: 1 k, 1 w, ±5%	C	0525-49	
R17	Resistor, Fixed, Composition: 82 k, ½ w, ±5%	C	0524-95	
R18	Resistor, Fixed, Composition: 10 k, ½ w, ±5%	C	0524-73	
R19	Resistor, Fixed, Composition: 91 k, ½ w, ±5%	C	0524-96	
R20	Resistor, Fixed, Composition: 180 k, ½ w, ±5%	C	0524-103	4
R21	Resistor, Fixed, Composition: 91 k, 1 w, ±5%	C	0525-96	
R22	Resistor, Fixed, Composition: 1 k, ½ w, ±5%	C	0524-49	5
R23	Same as R22			
R24	Resistor, Fixed, Composition: 47 k, ½ w, ±5%		0524-89	
R25	Resistor, Fixed Film: 475 k, 1 w, 1%	AH	A-01116-566	

TABLE OF REPLACEABLE PARTS (Continued)

Reference Designation	Description	Mfr. Code	Narda Part No.	Quantity Per Unit
R26	Resistor, Fixed Film: 137 k, 1 w, 1%	AH	A-01116-514	
R27	Resistor, Fixed Film: 475 k, 1 w, ±1%	AH	A-01116-566	
R28	Resistor, W.W.: 36.5 k, ½ w, 1%	AV	A-01135-455	
R29	Resistor, W.W.: 5 k, var, 2 w, 10%	U	A-01189-502	
R30	Resistor, W.W.: 68.1 k, 1 w, ±1%	AV	A-01136-481	
R31	Same as R20			
R32	Same as R22			
R33	Resistor, W.W.: 78.7 k, ½ w, 1%	AV	A-01135-487	
R34	Same as R22			
R35	Resistor, Fixed, Composition: 1 meg., ½ w, ±5%	C	0524-121	2
R36	Resistor, W.W.: 100 k, 20 w	T	A-01112-104	4
R37	Same as R36			
R38	Same as R36			
R39	Resistor, W.W.: 200 k, ½ w, 1%	AV	A-01135-530	
R40	Resistor, Fixed Film: 422 k, ½ w, 1%	AH	A-01115-561	2
R41	Same as R40			
R42	Resistor, Fixed Film: 249 k, ½ w, 1%	AH	A-01115-539	1
R43	Resistor, Composition: 25 k, var, 2 w	U		1
R44	Resistor, Var, Composition: 50 k, 2 w, 20%	U	A-01168-503	1
R45	Resistor, W.W.: 50 k, 5 w, 1%	BU	A-01130-3	1
R46	Same as R22			
R47	Resistor, W.W.: 237 k, 10 w, 1%	BU	A-01130-2	4
R48	Same as R47			
R49	Same as R47			
R50	Same as R47			
R51	Resistor, Fixed, Composition: 3.3 Ω , 1 w, 5%	C	0525-156	1
R52	Resistor, W.W.: 5 , var, 2 w	U	A-01186-050	1
R53	Resistor, Fixed, Composition: 200 Ω , 2 w, ±5%	C	0526-32	2
R54	Resistor, Fixed, Composition: 16 Ω , 1 w, 5%	C	0525-6	1
R55	Resistor, Fixed, Composition: 2.2 meg, 1 w, ±5%	C	0525-129	1
R56	Not used			
R57	Resistor, Fixed, Composition: 330 k, ½ w, ±5%	C	0524-109	1
R58	Resistor, Meter Shunt: 0.666 Ω , 100 ma, ±2%	M	B-02505-1	1
R59	Resistor, Meter Shunt: 0.286 Ω , 200 ma, ±2%	M	B-02505-2	1
R60	Resistor, Fixed Film: 113 Ω , 1 w, ±1%	AH	A-01116-206	1

TABLE OF REPLACEABLE PARTS (Continued)

Reference Designation	Description	Mfr. Code	Narda Part No.	Quantity Per Unit
R61	Resistor, Fixed Film: 46.4 Ω , 2 w, 1%	AH	A-01117-165	1
R62	Resistor, Fixed, Composition: 10 Ω , 1 w, ±5%	C	0525-1	1
R63	Resistor, Var, W.W.: 250 Ω , 2 w, ±10%	U	A-01189-251	1
R64	Resistor, Fixed, Composition: 100 Ω , 2 w, ±5%	C	0526-25	1
R65	Resistor, Fixed, Composition: 2.4 meg, 1 w, ±5%	C	0525-130	4
R66	Same as R65			
R67	Same as R65			
R68	Same as R65			
R69	Resistor, Fixed Film: 357 k, 2 w, ±1%	AH	A-01117-554	5
R70	Same as R69			
R71	Same as R69			
R72	Same as R69			
R73	Resistor, Fixed Film: 215 k, 2 w, ±1%	AH	A-01117-533	2
R74	Same as R73			
R75	Resistor, Fixed Film: 287 k, 2 w, ±1%	AH	A-01117-545	1
R76	Same as R69			
R77	Resistor, Fixed, Composition: 10 Ω , ½ w, ±5%	C	0524-1	4
R78	Same as R36			
R79	Same as R36			
R80	Same as R36			
R81	Not used			
R82	Resistor, W.W.: 5 k, 5 w, ±5%	T	A-01110-502	1
R101	Same as R13			
R102	Resistor, W.W.: 2 k, 5 w, ±5%	T	A-01110-202	1
R103	Same as R3			
R104	Resistor, Fixed, Composition: 18 k, 1 w, ±5%	C	0525-79	1
R105	Resistor, Fixed, Composition 75 k, 2 w, ±5%	C	0526-94	4
R106	Same as R105			
R107	Same as R105			
R108	Resistor, Fixed, Composition: 270 k, 2 w, ±5%	C	0526-107	2
R109	Same as R108			
R110	Resistor, Fixed, Composition: 470 k, ½ w, ±5%	C	0524-113	1
R111	Resistor, Var, Composition 250 k, 2 w, ±10%	U	A-01152-254	1
R112	Resistor, Fixed Film: 909 k, 1 w, ±1%	AH	A-01116-593	2

TABLE OF REPLACEABLE PARTS (Continued)

Reference Designation	Description	Mfr. Code	Narda Part No.	Quantity Per Unit
R113	Resistor, Fixed Film: 453 k, 2 w, ±1%	AH	A-01117-564	2
R114A,B	Resistor, Var, Comp; Dual Sect, 100 k, 2 w, ±10%, 25 k, 2 w, ±10%	U	B-02155-1	
R115	Same as R113			
R116	Resistor, Variable: 300 k, 5 w, ±5%	AR	B-02151-304	1
R117	Resistor, Fixed, Composition: 270 k, ½ w, ±5%	C	0524-107	1
R118	Resistor, Fixed Film: 178 k, 1 w, ±1%	AH	A-01116-525	1
R119	Resistor, Fixed, Composition: 510 k, ½ w, ±5%	C	0524-114	1
R120	Same as R64			
R121	Same as R105			
R122	Same as R112			
R123	Resistor, Fixed, Composition: 20 meg, ½ w, ±5%	C	0524-152	1
R124	Resistor, Fixed, Composition: 15 meg, ½ w, ±5%	C	0524-149	1
R125	Same as R77			
R127	Same as R9			
R128	Same as R53			
R129	Same as R77			
R130	Resistor, Var, W.W.: 5 Ω , 2 w, 20%	U	A-01186-050	1
R201	Same as R15	C	0524-97	1
R202	Resistor, Fixed, Composition: 10 k, 2 w, ±5%	C	0526-73	1
R203	Resistor, Fixed, Composition: 2.2 k, 1 w, ±5%	C	0525-57	1
R204	Resistor, Var, Composition: 50 k, 2 w, 20%	U	A-01177-503	1
R205	Resistor, Var, Composition: 100 k, 2 w, 20%	U	A-01171-104	1
R206	Resistor, Fixed, Composition: 36 k, ½ w, ±5%	C	0524-86	1
R207	Resistor, Fixed, Composition: 2 meg, ½ w, ±5%	C	0524-128	2
R208	Same as R2			
R209	Same as R20			
R210	Same as R20			
R211	Same as R2			
R212	Resistor, Fixed, Composition: 8.2 k, 2 w, ±5%	C	0526-71	1
R213	Resistor, Fixed, Composition: 10 k, 2 w, ±5%	C	0526-73	1
R214	Resistor, Fixed, Composition: 5.1 k, 2 w, ±5%	C	0526-66	1
R215	Same as R205			

TABLE OF REPLACEABLE PARTS (Continued)

Reference Designation	Description	Mfr. Code	Narda Part No.	Quantity Per Unit
R216	Resistor, Var, Composition: 5 k, 2 w, 20%	U	A-01171-502	1
R217	Resistor, Fixed, Composition: 47 k, 1 w, ±5%	C	0525-89	1
R218	Resistor, Fixed, Composition: 3.3 k, ½ w, ±5%	C	0524-61	1
R219	Same as R207			
R220	Resistor, Var, W.W.: 10 k, 4 w, ±10%	U	A-01187-103	1
R221	Resistor, Fixed, Composition: 68 k, 1 w, ±5%	C	0525-93	1
R222	Same as R 35			
R223	Resistor, Fixed, Composition: 560 Ω , ½ w, ±5%	C	0524-43	1
R224	Resistor, Fixed, Composition: 68 k, ½ w, ±5%		0-524-93	1
S1	Switch, SPST, Toggle	E	A-01650-6	1
S2	Switch, DPDT, Toggle	E	A-01650-8	1
S3	Switch, SPDT, Lever	BY	A-01645	1
S4	Switch, 2P 3 pos. Wafer	BD	B-02661	1
S101	Switch, SP 3 pos., Wafer	BD	B-02662	1
S201	Switch, 3P 6 pos., Wafer	BD	B-02660-1	1
T1	Transformer: Filament, 2 Secondaries	AI	C-02409	1
T2	Transformer: Variable	BN	D-02407	1
T3	Transformer: Power	AJ	C-02411	1
T4	Transformer: Power	AJ	C-02408	1
T101	Transformer: Power	AJ	C-02410	1
V1	Tube, Electron: 866A	L	A-01075	2
V2	Same as V1			
V3	Tube, Electron: 6CD6GA	L	A-01036	3
V4	Same as V3			
V5	Same as V3			
V6	Tube, Electron: OA2	L	A-01001	2
V7	Tube, Electron: 6AQ5	L	A-01021	1
V8	Tube, Electron: 5Y3GTA	L	A-01013	1
V9	Tube, Electron: 12AX7	L	A-01065	5
V10	Same as V9			
V11	Same as V9			
V12	Same as V9			
V13	Tube, Electron: 5651	L	A-01084	2
V101	Tube, Electron: 6AX4GT	L	A-01024	2
V102	Same as V101			
V103	Same as V7			
V104	Same as V9			
V105	Same as V13			
V106	Same as V6			
V107	Tube, Electron: 6X4	L	A-01060	1
V201	Tube, Electron; 6D4	L	A-01040	1
V202	Tube, Electron: 6U8	L	A-01057	1
V203	Tube, Electron: 12AU7	L	A-01064	1
V204	Tube, Electron: 6CL6	L	A-01039	1

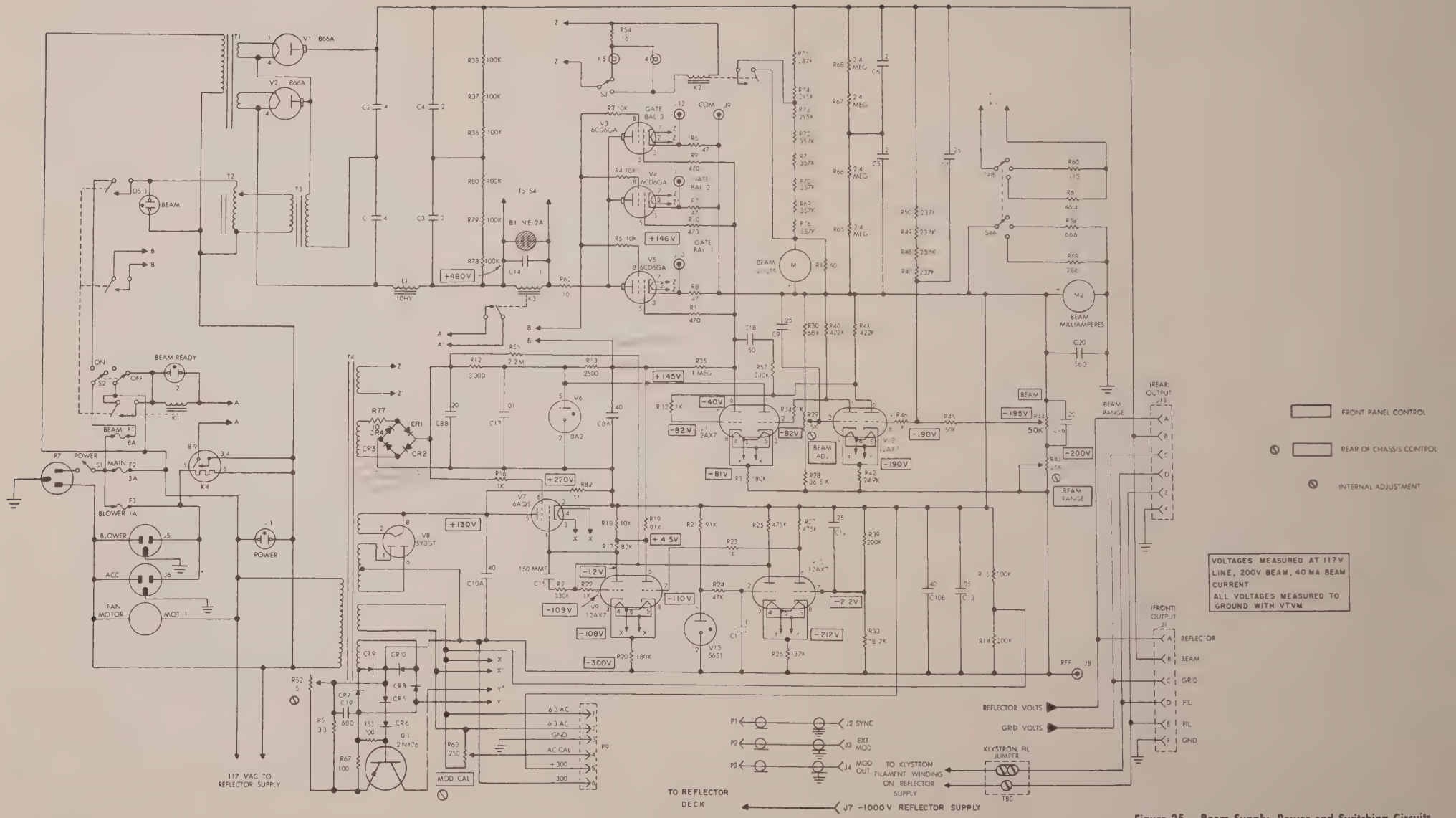


Figure 25. Beam Supply, Power and Switching Circuits, Schematic Diagram

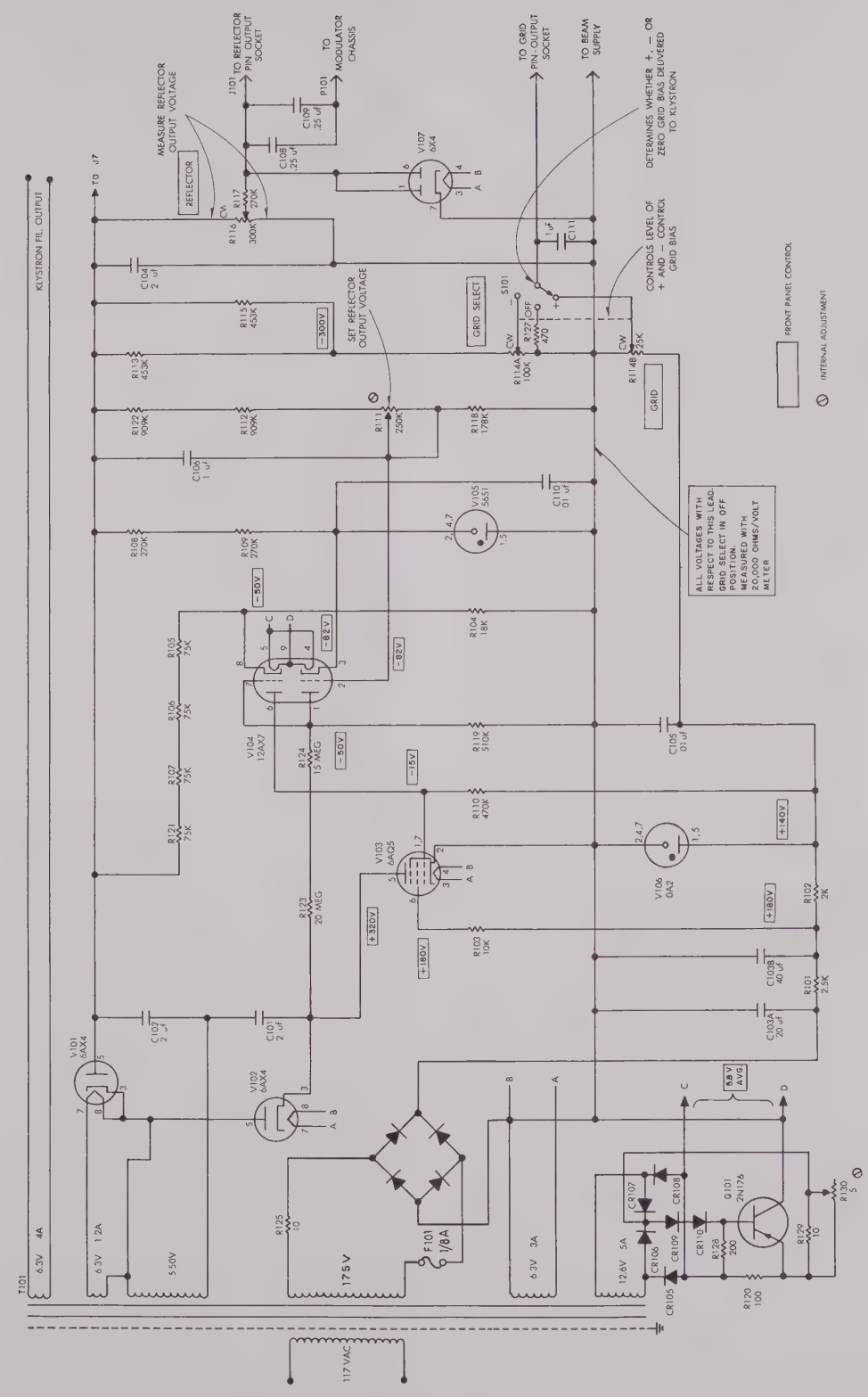


Figure 26. Reflector Deck, Schematic Diagram

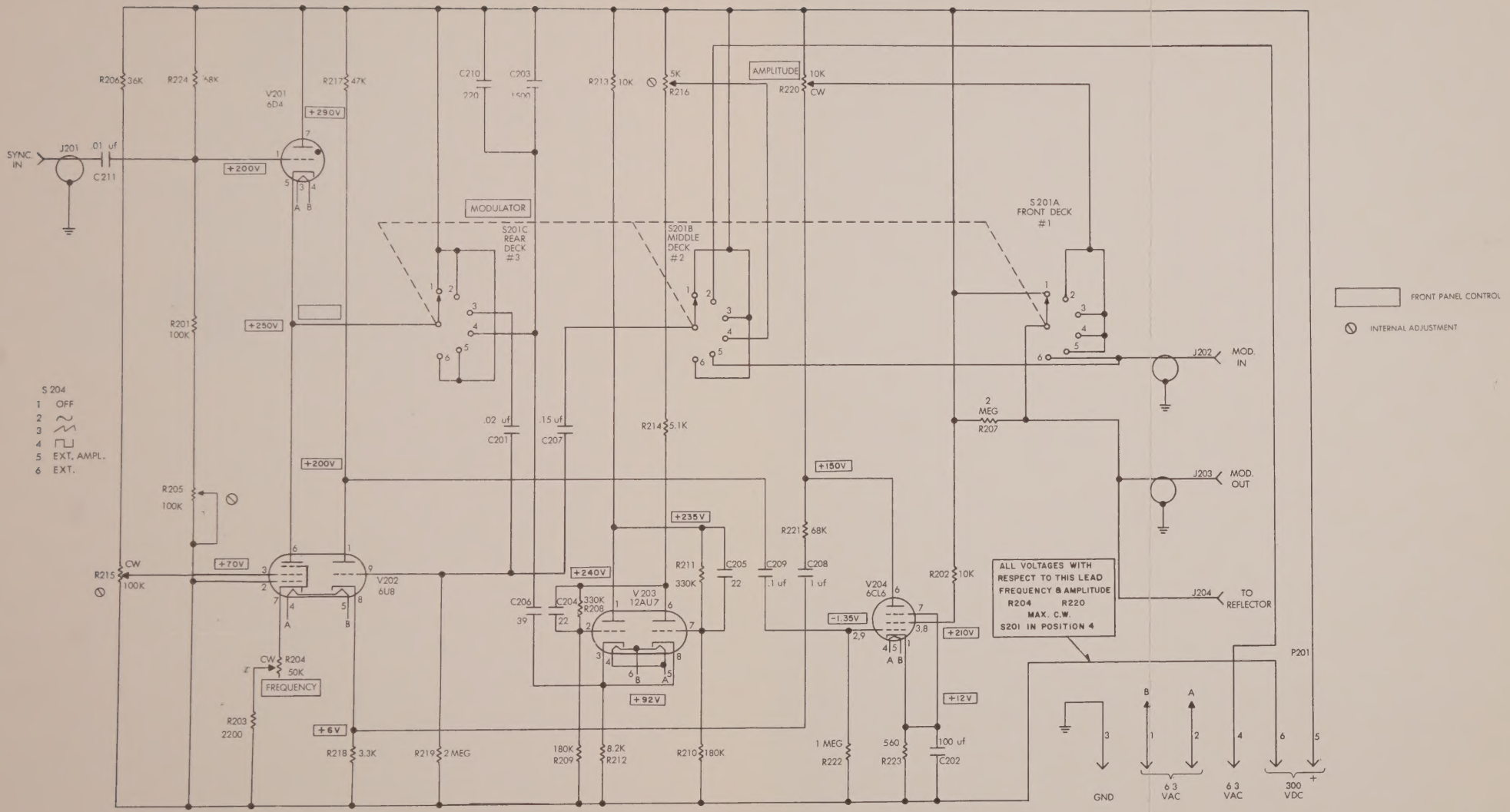
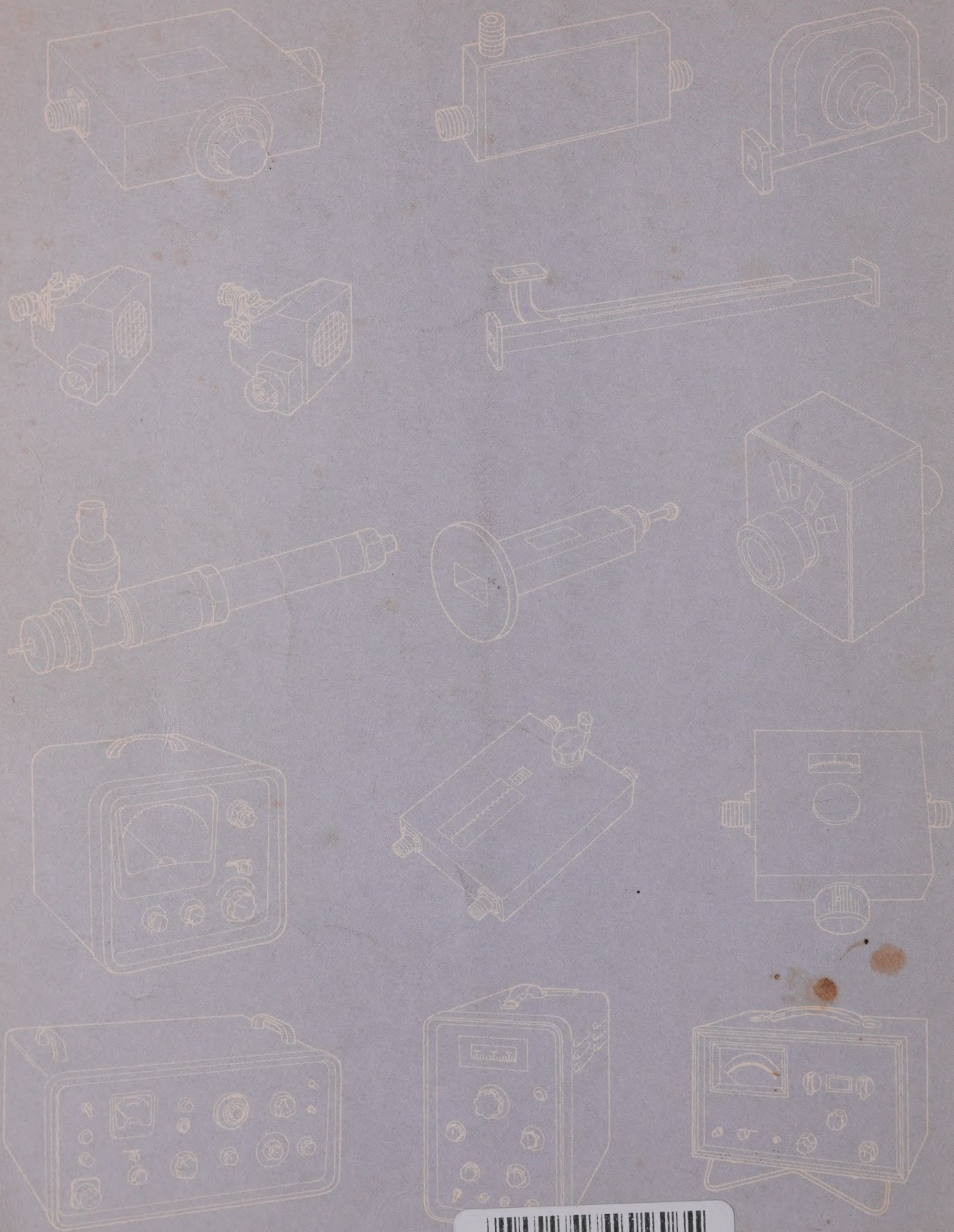


Figure 27. Modulator, Schematic Diagram



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